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Chemical Power Transmission.

In a recent address before the American Chemical Society on the electrochemical industries of Niagara Falls—a full account of which will be found elsewhere in this issue—Mr. FitzGerald mentions an interesting series of new commercial compounds now being made by the Roessler & Hasslacher Co. It is a series of peroxides with energetic oxidizing properties: calcium peroxide for the sterilization and preservation of foods, for ageing wines and for therapeutic purposes, magnesium peroxide for sterilizing water, zinc peroxide for antiseptic dressings, and fused sodium peroxide—or "oxone"—stable under ordinary conditions in air, but giving off oxygen in a most convenient manner when in contact with water. This commercial development is the direct outcome of systematic research work carried out in the research laboratory of the Roessler & Hasslacher Co.—certainly a gratifying result which should encourage our chemical manufacturers to establish more research laboratories. But this is a point on which we comment in a separate note in this issue. The development is also interesting in another respect. All the compounds mentioned have a high chemical energy content, and it is on this account that they are useful. A large amount of chemical energy is stored in them, it is "latent" under ordinary conditions, but it may be gotten out of them whenever or wherever necessity arises. By transporting compounds of high chemical energy content to a distant place, we transmit simultaneously the energy to that place. Chemical energy transmission, as we may term this, has some features in common with other systems of energy transmission and other features distinctly characteristic for chemical energy transmission alone.

The principle of the conservation of energy is at the bottom of all modern theories of physics and chemistry. The transformation of different forms of energy into each other is at the bottom of our modern civilization. All big engineering accomplishments of the last hundred years—from the steam engine up to electric power transmission, electric lighting, electric traction—are examples of a change of one form of energy into another. Under given conditions we may advantageously consider the energy as a product of two factors—the capacity factor and the intensity factor, to use the terms of Ostwald. The total amount of energy is the same, if the product of capacity factor and intensity factor is the same. But for the engineering applications it makes an enormous difference whether we make the capacity factor small and the intensity large, or the former large and the latter small. Thus in water-power developments we may consider the amount of water passing during a certain time as the capacity factor and the difference of level—the height of the fall—as the intensity factor. If we have two falls, one with a height 100 times

greater than the other, but with a 100 times smaller amount of water, then the energy is the same in both cases, but the difficulties of developing the higher fall will be considerably smaller. With electric energy we have the current passing in a certain time—the coulombs—as capacity factor, the pressure—the volts—as intensity factor. Here, again, it is important for transmission purposes to use a high intensity factor, a high voltage, since the loss in transmission will then be a minimum. With chemical energy we may consider the mass or weight of the reagent as the capacity factor and its specific chemical potential (which determines the activity of the reaction) as the intensity factor. For transmission purposes it is again preferable to have the capacity factor, the mass, small, to save cost of transportation. Thus for chemical power purposes those chemical compounds are chiefly of importance which have a very high energy content; and this is the reason why electrochemical engineering is so intimately connected with chemical power transmission problems. In many cases only electrochemical methods can cheaply produce those high-energy compounds, and for this reason many chief reagents for chemical energy transmission are products of electrochemical industries.

Chemical power transmission has two distinct advantages over other forms of power transmission. First, it is not bound to a fixed route; it requires no line wires. Second, it is not bound to a certain time; it is not necessary to use the transmitted energy at once or to provide special means for storing it. Chemical energy is in itself essentially stored, latent energy, and is used, therefore, in connection with other systems of power transmission for storing purposes, as in the case of storage batteries in electric power systems. Chemical energy storage and transmission is indeed capable of a surprisingly large number of useful applications, of which probably only a small number have so far been developed. The whole development is apparently only in the beginning, being an outcome of the development of electrochemical industries. Thus, the aluminothermic reaction with its steadily increasing number of practical applications is an example. Whether tramway rails are welded by thermit or the broken sternpost of a steamer is repaired by thermit, in any case the energy which is so conveniently developed there by the chemical reaction, has been transported with the aluminium to that place from the works of the Pittsburg Reduction Co. at Niagara Falls. If only thermit is on hand, we are enabled to produce molten soft steel at a very high temperature, wherever it is wanted and whenever it is wanted. Analogous remarks will be true of the silicothermic reaction when once introduced into practice. Any acetylene lighting plant, wherever it may be situated, utilizes the energy which was stored in the calcium carbide at the electric furnace plant. The calcium carbide gives the acetylene where it is wanted and when it is wanted. In the same way "oxone" will be found useful for the convenient production of oxygen. All these examples show the great convenience of the general method, and there are no reasons why a great many other examples of this general principle should not be found. But this convenience in use and this practical simplicity should not mislead anyone to think that the development of these methods has been a simple matter. Since all these reagents have a high energy content they are always willing to give their energy up—even when this should not be desired. Careless handling and transport of such reagents involves dangers which must be avoided in practical use. In all examples mentioned above much work has been necessary to bring the methods to such perfection as to become simple in practice and free from danger for general use.

Metallurgical Research Laboratories.

Metallurgical research laboratories are comparatively uncommon in this country. They, however, do exist, and their presence is encouraging. Years ago, when the iron business was called upon to furnish iron of regular composition for Bessemer plants, analytical laboratories were few and insignificant. Now, however, few iron furnaces or smelting plants of any size are without a laboratory for analyzing the samples of the works. This change has come about in spite of the opposition of the so-called "practical men." It is believed the research and experimental laboratory will win a similar victory. Wisely and liberally administered by a progressive man, such a laboratory is most valuable. Foolishly and extravagantly managed, it is worse than useless. Here, as in all else, the personal equation determines the fate of the enterprise.

Arguments for a research department are not many, but these few arguments are irresistible. A metallurgical laboratory has a splendid chance to test the methods of analysis and samplings. This is an important branch of metallurgy, as important and vital as are foundations in civil engineering. Such work should be removed entirely from the "works-laboratory," and can best be done by a well-trained and well-paid specialist. Next, the laboratory can make cheaply and accurately determinations of the physical constants of the reactions, worked on a large scale in the plant. The application of physical chemistry to metallurgy is too important to be discussed here, but using the abbreviated phrase—"physical metallurgy"—of one of our correspondents, we can state our opinion that the field will be found most prolific for hard, systematic original work in the next decade, and that from this scientific work will come results that can be measured only in millions of dollars. For instance, in a lead furnace, which is often as flirtatious as a coquettish woman, slags low in silver and lead are the essential. This fact depends largely on the temperature of formation, rate of formation, and temperature of fusion of these slags, and their resultant physical properties. If the slags were tested from time to time, and it were found by experiment which slags had the requisite physical properties, a large financial gain might easily ensue.

Again, there are often numerous new proposals that come up in the daily routine of work. To try these out on a large scale is expensive. With a regular research department this can be accomplished cheaply and accurately. Experimenting

is the price of progress. The question, "will it work," is best answered, "try and see." To do this, requisite experimental work with certainty is hard without the regular organization. With an organization it is easy. Such other uses as the calibrating of pyrometers, checking scales, and so forth, need not be elaborated, for they are but minor advantages. The essence of the whole matter is the perfect welding of theory and practice. The research department should be in closest touch with the actual operations. Its head should be above all else a man of tact, a man who knows how to deal with young college graduates who are full of energy and theoretical knowledge and workmen who are conservative and have practical experience. He should have a good theoretical training, and he must have been "through the mill" himself. Needless to say, only a high-priced man is worth his pay in this place. He must be on the warmest and most sympathetic terms with the chief of the operating department and the chief of the business department, and should be subject to the former's orders. Such a man is the ideal, and hard to secure. Perhaps his rarity is the cause of distruct on the part of the directors of most concerns for anything called an experimental laboratory. We know of one instance where the laboratory was called the "experimental shop," to disabuse the directors' mind of this delusion. But it will not always continue thus. The cause is found in the fact that in the past experimenting has been done inefficiently. The results have been bad and the cost excessive. When once business men are convinced that a course is wise and productive of financial returns they are only too anxious to follow that course. This the experience in the electrical field proves beyond a doubt.

Genesis of Chemical Elements.

In our April issue of last year we commented on J. J. Thomson's remarkable and beautiful scheme of an atom being a structure of shells of corpuscles, or negative electrons, within a sphere uniformly charged with positive electricity. Starting from a few fundamental suppositions, Thomson arrived, by strict mathematical analysis, at an explanation of the properties which chemical elements are known to possess, and especially of the periodic system of elements. While in this investigation Thomson's mathematical genius contributed largely to his triumph—one of the greatest ever achieved in theoretical physics—yet it should not be forgotten that Thomson did not follow the easy path of those who before him put forward speculations on the constitution of atoms. Thomson first proved the existence of his corpuscles in his researches on the nature of cathode rays, he determined their charge, their mass and properties. He proved them to be identical when produced from different kinds of matter and under different conditions, and then he devised the scheme of the rôle which they play in the constitution of matter. If his theory is right, if the atom is no longer indivisible, but represents itself a complicated system of corpuscles or electrons, and if the atoms of the different elements are all made up of the same kind of corpuscles and differ among themselves only in the number and configuration of corpuscles, then it is no longer absurd to consider the possibility of the tranmutation of chemical elements. As a matter of fact we are forced to such considerations by the established phenomena of radioactivity. The only satisfactory explanation, or at least adequate coördination, of the mass of facts found concerning radioactivity is that proposed by Rutherford and Soddy, that the atoms of the radioelements suffer spontaneous disintegration, and that each disintegrated atom passes through a succession of well-marked changes (metabolons), accompanied in most cases by the emission of alpha rays. In radioactive processes we are dealing with changes ... the atoms themselves, and are watching the true gradual destruction of the radioactive atom. This itself is a metabolon; this means, it must have a parent element, and much circumstantial evidence has been produced in favor of the view that uranium is the parent of radium, especially by Boltwood. In any disintegration series, equilibrium will be attained and the relative quantities of the various members of the series, expressed in terms of the quantity of the parent element, must have a definite value, representing the inverse ratio of the rates of change of the transition form and parent element respectively. Boltwood, in analyzing a great many minerals, containing very varying proportions or uranium, has found in each case the expected proportionality to exist between the quantities of uranium and radium. Now Soddy, in a paper in the June issue of the *Philsophical Magazine*, produces direct evidence of the paternal relation of uranium towards radium. A quantity of uranium, originally free from radium, was proven to develop later the unmistakable characteristics of the radium emanation. This, taken together with the older spectroscopic proof by Ramsey and Soddy, of the production of helium from radium, enables Soddy to sketch the general outline of this disintegration series.

This disintegration series is as follows, the figures in parenthesis representing the atomic weight: The parent is uranium (238), metabolons are radium (225) and polonium (212); the final element is either lead (206.9) or bismuth (208.5). The alpha particles emitted during the different changes and causing the lowering of the atomic weight of the residue, form helium. In favor of the view that lead is the final product, Boltwood has cited the fact that lead persistently appears as a constituent of the uranium-radium minerals. Certainly, we are here in the midst of a most important phase of the development of natural science. There is much promise of important results from further conscientious and systematic experimental work, while with respect to the theory we may expect to see Thomson follow up his own explanation of the periodic system by a scheme of the evolution of chemical elements, just as Ernst Haeckel followed Darwin's work, and determined the pedigree of living nature. To those who judge everything from its immediate and direct commercial value, we may point out that radioactive processes are spontaneous. With none of our strongest egencies, like application of heat, etc., are we able to influence in the least the rate of change of radioactive processes. From the experimental evidence now available, there is no hope that the modern chemist will solve commercially the problem of the old alchemist of making gold from dirt. This will remain, as in the past, within the domain of the cyanide engineer.

American Chemical Society.

The thirty-second general meeting of the American Chemical Society was held in Buffalo, N. Y., from June 22 to 24, according to the programme published in our last issue, and turned out to be a full success in every respect. There was a very satisfactory attendance. The last printed list of members and guests who registered showed an attendance of 148.

The sessions for the reading and discussion of papers were held according to the programme, and were well attended, while the social functions were highly enjoyed.

On Thursday afternoon a large number of the members enjoyed a drive through many interesting parts of the city in carriages provided by the committee, while others visited the Gratwick laboratory. The same evening Mr. F. A. J. FitzGerald, of Niagara Falls, read a paper in one of the parlors of the Iroquois Hotel on the electrochemical industries of Niagara Falls, which brought out a large attendance. The paper, an abstract of which is printed on another page of this issue, was received with much enthusiasm. The new materials now made on a commercial scale in Niagara Falls—acetyvone, peroxides and sodium perborate—excited a great deal of interest; the fused sodium peroxide ("oxone") came in for the lion's share of attention. After the conclusion of Mr. FitzGerald's address an informal luncheon was served with the compliments of the management of the Iroquois Hotel, the convention headquarters.

Directly after the afternoon session on Friday, which concluded at 3 o'clock, the majority of the members took advantage of the opportunity to take a trip on Buffalo harbor in the largest and most modern of the fire boats. An excellent opportunity was afforded of seeing the Lackawanna Steel Co's plant from the water side, after which the boat was moored to one of the breakwaters, and an exhibition given of its fire-fighting qualities. A few of those present were unfortunate enough to be too close to the fire nozzle when the water was first turned on, and suffered somewhat in consequence. After this a short run was made up the Buffalo River, and the boat returned to her mooring at the foot of Main Street. About 100 of those present participated in the subscription banquet at the Hotel Iroquois on Friday evening.

Abstracts of the papers presented will be given later, when they have been published in the Journal of the Society. Besides Mr. FitzGerald's suggestive address, a paper, presented by Mr. Chas. B. Jacobs, should be of interest to our readers, since it deals with some observations on the *electrolytic deposition of alloys from mixed solutions*. The method described by Mr. Jacobs is now successfully used on a commercial scale by a lithograph company.

In the simultaneous deposition of two metals from a mixed solution of their salts, the difficulty is met that the solution attacks and dissolves the more electro-positive metal after deposition. This may be prevented by the use of two anodes, one of the more electropositive and the other of the more electronegative metal, connected to separate generators running at different voltages, the current returning through the cathode in the bath by a common third conductor to the generators.

Alloys of zinc and nickel and zinc and copper were deposited in this manner from neutral sulphate solutions. With cyanide solutions of copper and zinc a great variety of brass work was plated from the same, by changing the voltage on either anode in order to throw down a brass running high in copper and low in zinc, or vice versa.

Visit of American Members of Society of Chemical Industry to Great Britain.

On the evening of June 17, a joint meeting of the Chemists' Club, the Society of Chemical Industry, the American Chemical Society and the American Electrochemical Society was held in the convention hall of the Chemists' Club in New York City, the object being to wish God speed to those who were about to leave for England to attend the annual general meeting of the Society of Chemical Industry and participate in the trip through the country.

The meeting was very well attended, nearly 200 members being present. Mr. T. H. Kiessig, as chairman of the meeting, expressed its good wishes to the departing members and Dr. Wm. H. Nichols, the president of the Society of Chemical Industry, answered in a forceful and humorous speech. At the conclusion of his speech he made a remark which will certainly be applauded by chemical engineers all over the country; namely, that "in the autumn when we come back from England, we will direct our energies toward securing a fine new home for the Chemists' Club and for chemical engineers in the United States."

The programme for the week in London from July 10 to July 16, has already been published in our June issue, page 212. The party will then proceed on July 17 to Nottingham; July 18 to Rowsley, Chatsworth, Baslow and Manchester; July 20 to Chester and Liverpool; July 22 to Newcastle; July 23 to Durham and back to Newcastle; July 24 to Tynemouth and Edinburgh; July 26 to Glasgow.

From the programme as issued it is evident that the greatest endeavors are being made to make the trip a most memorable one, never to be forgotten by those who are lucky enough to participate in it. An alphabetical list of those participating in the visit to England is herewith given.

Mr. William A. Alpers and Miss Alpers, New York City; Mr. and Mrs. Theo. Armstrong and son, Philadelphia Pa.; Mr. F. E. Atteaux, Boston, Mass.; Dr. Leo. H. Backeland, Yonkers, N. Y.; Mr. and Mrs. Eugene Barry, Ayer, Mass.; Dr. Charles Baskerville, New York City; Mr. Victor G. Bloede, Baltimore, Md.; Mr. Walker Bowman, New York City; Dr. E. Burkard, Garfield, N. J.; Dr. Nicholas Murray Butler, New York City; Dr. and Mrs. Eugene A. Byrnes, Washington, D. C.; Mr. and Mrs. Walter M. Chadwick and Miss Chadwick, Bayonne, N. J.; Dr. and Mrs. Charles F. Chandler, New York City; Mr. Alan A. Claflin, Littleton, Mass.; Dr. Virgil Coblentz, New York City; Dr. W. A. Converse, Chicago, Ill.; Mr. and Mrs. M. L. Davies, Bay City, Mich.; Dr. A. R. L. Dohme, Baltimore, Md.; Dr. William Dreyfus, New York City; Mr. B. P. Ducas, New York City; Mr. and Mrs. Chas. E. Eager, Boston, Mass.; Mr. Peter Fiebiger, New York City; Mr. Herman Frasch, New York City; Mr. and Mrs. Wm. S. Gray, and Miss Gray, New York City; Mr. Martin L. Griffin, Mechanicsville, N. Y.; Mr. and Mrs. Wilson Hanna, Boston, Mass.; Mr. Henry Hochstetter, Cincinnati, Ohio; Mr. William F. Hoffmann, Newark, N. J.; Mr. and Mrs. Henry Howard, Boston, Mass.; Dr. and Mrs. Alex. C. Humphreys, Hoboken, N. J.; Mr. Clarence M. Joyce, Arlington, N. J.; Mr. Alex. S. Kirkman, Brooklyn, N. Y.; Mr. H. J. Krebs and Miss Krebs, Wilmington, Del.; Professor Leonard P. Kinnicutt, Worcester, Mass.; Professor W. R. Lang, Toronto, Canada; Mr. Ashton Lee, Lawrence, Mass.; Dr. E. G. Love, New York City; Mr. and Mrs. Houston Lowe, Miss Lowe, Dayton Ohio; Mr. W. E. Lummis, Boston, Mass.; Miss Mary S. Lynne, Pittsburg, Pa.; Mr. and Mrs. Hugo Lieber, New York City; Professor and Mrs. C. F. Mabery, Cleveland, Ohio; Mr. F. Grant Marriott, Toronto, Canada; Mr. H. A. Metz, New York City; Mr. Ambrose Monell, New York City; Dr. Russell W. Moore, New York City; Mr. and Mrs. St. Clair McKelway, Brooklyn, N. Y.; Mr. William A. Nash, New York City; Dr. and Mrs. William H. Nichols and Miss Nichols, New York City; Mr. and Mrs. E. Remington Nichols and Miss Nichols, New York City; Dr. William A. Noyes, Washington, D. C.; Mr. and Mrs. W. F. Oburg and son, Boston, Mass.; Dr. T. J. Parker, New York City; Mr. Albert Plaut, New York City; Mr. and Mrs. G. G. Pond, State College, Pa.; Mr. C. Propach, Chicago, Ill.; Mr. Herman S.

Riederer, Newark, N. J.; Mr. B. E. Schlesinger, Boston, Mass.; Dr. H. Schweitzer, New York City; Professor A. W. Smith, Cleveland, Ohio; Mr. James Speyer, New York City; Mr. I. F. Stone, New York City; Mr. and Mrs. Geo. H. Taber, Pittsburg, Pa.; Mr. and Mrs. Henry D. Tichenor, New York City; Dr. and Mrs. Maxmilian Toch, New York City; Mr. W. H. Van Winckel, Toronto, Canada; Mr. I. D. Varshnei, Boston, Mass.; Mr. and Mrs. S. S. Voorhees, Washington, D. C.; Mr. Louis I. Waldman, Albany, N. Y.; Dr. Max Wallerstein, New York City; Dr. and Mrs. Martin Waldstein, New York City; Dr. Ida Welt, New York City; Mr. Clarence B. White, Youngstown, Ohio; Dr. H. W. Wiley, Washington, D. C.; Mr. R. C. Woodcock, New York City; Mr. and Mrs. C. B. Zabriskie, New York City.

American Foundrymen's Association.

The tenth annual convention of the American Foundrymen's Association was held in New York City, from June 6 to 8. The attendance was beyond the 200 mark, and ran up on the last day to almost 250. There was no local committee or entertaining committee, and nothing had been arranged on the official programme for the entertainment of the members on the evenings. Nevertheless, the convention was a most enjoyable affair, perhaps just on account of the informal nature of its social features. There is a very healthy professional sentiment which holds the members of the Association together, while not enough praise can be given to the splendid work of the indefatigable secretary, Dr. R. Moldenke, who is the real soul of the Association.

Mr. Thos. D. West (T. D. West Foundry Co., Sharpsville, Pa.) was elected president for the coming year. The next convention will be held at Cleveland.

The sessions were held partly in the Grand Central Palace and partly in Columbia University. A great many papers were presented. Those of metallurgical interest are abstracted below.

Fan Blowers vs. Positive Pressure Blowers.

A paper, by Mr. H. E. Field, on this subject was based on a report made to the Pittsburg Foundrymen's Association last year by a committee appointed by that association. Four tests were made with two Sturtevant fans and one Connersville positive-pressure blower, supplying a cupola which was lined to 54 inches. The blower and the fans were electrically driven. The electrical power, the motor speed, and the blast pressure were measured during four regular cupola heats.

The main point of difference between the two types of machines is this: With the positive-pressure blower the amount of air delivered is not dependent upon the size of the opening. With the fan this is the case. A fan will deliver a maximum amount of air only as long as there is a free opening, and when this opening is made smaller the fan will deliver less air. As the opening grows smaller, and consequently the amount of air delivered grows less, there will be a corresponding less amount of horse-power required to run the fan. The horse-power consumed then in driving a fan is in a measure proportionate to the amount of air delivered by the fan. The action of a positive pressure blower is exactly opposite, since it insists upon a given amount of air being delivered per revolution. The larger the opening the less horse-power will be required to deliver a given amount of air through that opening.

With a fan blower the piping should be as short and free from curves as possible. With the positive-pressure blower isis is not so important.

The fan consumes the greatest power at the beginning, and least power when the blast pressure has arisen to its maximum; after that to the end of the run the power required by the fan increases again slightly. On the other hand, the blower consumes its least power at the beginning of the run; the power required then rises very rapidly, and reaches a maximum over twice as great as the initial, at the same time as the blast pressure reaches its maximum. In the last part of the heat the blower power decreases, ending with about 70 per cent of the maximum.

The electrical energy consumed by the motor for the blast in kw-hours per ton of iron melted was found to be in the four tests as follows:

With fan (two tests), 3.41 and 2.76; with positive-pressure blower, 2.86 and 2.63.

In the second fan test very light scrap was used, of such shape that it kept the cupola open and gave freer passage for the air. Under these circumstances the performance of the fan was practically equal to that of the blower.

Mr. Field concludes that an escape valve, or relief valve, should not be used with positive pressure blowers, since this destroys their ability to keep the cupola open, and makes the blower equivalent to a fan.

The paper elicited considerable discussion, in which especially Messrs. F. W. Stickle, H. E. Field and D. Spence participated.

Aluminothermics.

Three papers were presented on practical applications of the aluminotherimic reaction. Mr. W. M. Carr gave a demonstration of the properties of thermit, and its use in welding and the like, while Mr. J. F. Webb discussed the use of thermit in a railroad shop, and Mr. G. N. Prentiss, the repair of driving wheels by thermit. It was reported by Mr. Webb that a broken locomotive frame was in one instance repaired in about 20 hours, counting from the time the engine came into the shop until the time it left to take out a train.

In the discussion of Mr. Carr's paper the use of "nickel-thermit" was brought out for introducing nickel into molten cast-iron, in order to increase the resistivity of cast-iron tanks against chemical action and to improve the strength, density and fineness of grain. Mr. E. Stütz stated that nickel thermit is now being used successfully in Germany in connection with the manufacture of alkali pots, the amount of nickel thus introduced into cast iron being about one-half of 1 per cent. Nickel thermit is now being introduced in this country for the same purpose.

A practical application of nickel thermit and titanium thermit was made on the occasion of the visit of the Association to the works of the International Steam Pump Co., in Harrison, N. J. A wide range of castings is produced at this plant, both in cast iron and brass. A feature of the visit was the pouring of a 1000-pound casting after nickel thermit had been introduced into the ladle. About 1 per cent, or 10 pounds of nickel thermit was used, this being poured from a small ladle into the ladle containing the cupola iron, when the latter was about half filled. Then the remaining iron was tapped out, and, lastly, there was added to the ladle of molten iron one-sixteenth of 1 per cent of titanium-thermit (a mixture of titanic oxide, aluminium and iron oxide). The object of the latter is to cleanse the iron, particularly to remove nitrides, and thus increase the density of the iron; and above all to stir the molten bath so thoroughly that the nickel which was introduced before is uniformly distributed through the molten bath.

Properties of Alloys.

A paper by Mr. P. Longmuir, Sheffield, England, on "Variations in the Properties of Alloys," was contributed by the *Metal Industry*, and was read by Dr. G. P. Scholl. It was illustrated by lantern slides.

The author gives an account of a series of tests on the influence of the casting temperature on the strength and ductility of brasses and other alloys. The highest tensile strength and ductility were obtained when the alloy was cast at a moderate or "fair" temperature, *i. e.*, one which is neither too high nor too low.

The chemical analyses in all cases showed exactly the same composition for all bars cast from a single ladle, although the

first bars were cast very hot, while the last were cast when the brass was quite dull; this shows that there is no burning-out of zinc during the process of pouring. Microphotographs of sections, however, showed the cause of the difference in strength ductility, since the finest and best interlocked grain results when the casting temperature is fair. From the experience of the author it would seem that when once an error has been made in using too high or too low a temperature of casting, no subsequent heat treatment will bring up the ductility and tensile strength to the possible maximum.

Determining Silicon in Pig Iron and Cast Iron.

Mr. H. E. Diller presented the report of the metallurgical section of the Association. The committee proposes the following method of determining silicon in iron:

"Weigh 1 gram of sample, add 30 c.c. nitric acid (1.13 specific gravity); then 5 c.c. sulphuric acid (conc.). Evaporate on hot plate until all fumes are driven off. Take up in water and boil until all ferrous sulphate is dissolved. Filter on an ashless filter, with or without suction pump, using a cone. Wash once with hot water, once with hydrochloric acid, and three or four times with hot water. Ignite, weigh and evaporte with a few drops of sulphuric acid and 4 or 5 c.c. of hydrofluoric acid. Ignite slowly and weigh. Multiply the difference in weight by 0.4702."

The committee recommended this method as one that sacrificed shortness to some extent to insure accuracy, and that left little to the judgment of the chemist. While it was recognized that it is almost impossible to get chemists to use a standard method in their daily work, the one proposed would serve as a check method in case of dispute between laboratories or between buyer and seller.

Effect of Manganese in Low-Silicon Cast Iron.

Mr. H. C. Loudenbeck presented results of tests on the effect of manganese on the chill and fraction of cast iron having a low percentage of silicon. He reached the following conclusions. Manganese may be used to an advantage in low silicon and chilling iron in the following cases: In mixtures where the percentage of scrap is large and the sulphur necessarily high (this will occur in a car-wheel mixture where usually a large portion of old metal is used), the result of this increase in manganese would be lower sulphur, lower combined carbon, less chill and greater strength.

Very often chilled plates are required, having hard-chilled faces and soft backs suitable for planing. Manganese, added in the right proportion, will reduce the tendency to mottle, and make a comparatively soft graphitic back.

In all cases where chilling irons are melted in a cupola and the sulphur is over 0.07 per cent, the iron can be strengthened by the [illegible] of ferromanganese or pig iron having a high percentage of manganese.

There are, however, some cases where the manganese should be kept low. In the manufacture of large hydraulic cylinders it is necessary to have a close, mottled iron to withstand the pressure and prevent leakage. If the manganese is too high this mottled structure is replaced by a coarse graphitic structure, which is not satisfactory for this class of work.

American Institute of Electrical Engineers.

The twenty-second general meeting of the American Institute of Electrical Engineers, held from June 19 to 23, at Asheville, N. C., had attracted not less than 250 members from all parts of the country. It was the first meeting held by the Institute in the South. The technical programme was excellent; twenty-four papers were presented and elicited good discussion. The social features of the convention were a reception and ball on the evening of June 20, a trolley ride to the Asheville Golf Club on the afternoon of June 21, and on the same evening a banquet, at which nearly 200 were present. Mr. T. C. Martin acted as toastmaster. President Lieb spoke in very complimentary terms on the South, and Mayor Barnard, of Asheville, replied in terms equally complimentary to the Institute. The president-elect, Dr. Schuyler Skaats Wheeler, responded to the toast "The Institute," Dr. C. P. Steinmetz to "Theory and Practice," Dr. S. Sheldon to "Technical Institutions," Mr. J. H. Finney to "Industrial Development of the South," and Dr. F. A. C. Perrine to "The Utilization of Natural Resources Through Electricity."

The only two papers of chemical or electrochemical interest are briefly abstracted below:

Constant-Current Mercury Arc Rectifier.

A paper, by Dr. C. P. Steinmetz, dealt with the use of a constant-current mercury arc rectifier system for operating direct-current series arc circuits from an alternating-current constant potential supply. The series of arc lamps is connected at one end with a tap brought out from the middle of the secondary of a constant-current transformer. The two terminals of the secondary coil are connected through two induction coils with the two graphite anodes of the mercury rectifier tube. The common mercury cathode is connected through an induction coil with the second terminal of the series of arc lamps. Two auxiliary mercury anodes near the cathode are used for starting the discharge (as described in the recent paper of E. Weintraub, May issue, p. 184).

A system of this kind has been in regular service for over a year, supplying a constant current of 3.8 amps. to twenty-five arc lamps in Schenectady. In this small plant of only 3.9-kw output an efficiency of 80 per cent and a power factor of 70 per cent is reached, between the constant-potential alternating current received from the primary distributing mains and the constant direct current sent into the arc circuit.

A New Carbon Filament.

A paper on this subject was presented by Mr. John W. Howell. It is well known that an ordinary incandescent filament in an evacuated lamp may be heated to excessive temperatures by the application of high current without producing any beneficial changes in the filament. To produce the effects described in the paper, the heat is externally applied to treated filaments at atmospheric pressures. The simple application of the highest attainable temperatures to the plain carbonized cellulose fiber, *i. e.*, the so-called "filament base," is also incapable of producing any considerable changes in the filament. This high temperature treatment of the base is, however, a beneficial step in the process described.

In attempting to graphitize carbon filaments it was discovered that treated filaments undergo very remarkable changes when subjected to the highest possible temperature of an electric resistance furnace. The furnace consisted of a carbon tube, held at the ends by large water-cooled copper clamps; the tube was imbedded in powdered carbon to prevent its combustion. The filaments were packed in small, cylindrical carbon boxes, which were fed into the heated tube. The temperature was usually between 3000° and 3700° C.

Under such firing the ordinary treated filament changes in appearance; its graphite coating looks as though it had been melted, and its specific resistance is greatly reduced. The resistance of one of these filaments, measured at ordinary temperature, may be reduced as much as 80 per cent by the firing.

The changed nature is also indicated by toughness and flexibility. It seems that the change is practically all in the treated coating and not in the base.

The most effective carbon filament now in general use operates at 3.1 watts per candle, and under accurate test conditions gives a useful life (to 80 per cent of its initial candle power) of about 500 hours. At the present time graphitized filaments that give the same useful life at about 2.5 watts per candle power, are being produced with a fair degree of uniformity.

The Electrochemical Industries of Niagara Falls.

An address on this subject, delivered on June 22 by Mr. FRANCIS A. J. FITZGERALD, of Niagara Falls, at the Buffalo meeting of the American Chemical Society, was highly interesting and suggestive in two respects; firstly, for the reason that Mr. FitzGerald treated the subject from an evolutionary point of view, observing the effects of those most important factors in evolution, the struggle for existence, the influence of environment, etc., in the development of the Niagara electrochemical industries, and secondly, because several new electrochemical products made commercially at Niagara Falls were here publicly discussed for the first time.

ALUMINIUM.

The aluminium industry is now about ten years old in Niagara Falls, and Mr. FitzGerald discussed briefly the enormous growth of the Pittsburg Reduction Co. in this period, which necessitated the erection of further large plants at Massena and Shawinigan Falls. Now more aluminium is manufactured in America than in all the rest of the world combined.

Mr. FitzGerald emphasized the effect which is produced on certain details of the process of manufacturing aluminium by the environment of cheap electric power. An expensive part of the manufacturing process is the preparation of the raw materials. Thus the bauxite used must undergo an elaborate chemical treatment to remove objectionable impurities such as iron, silicon, etc., as these would enter into the metal. Mr. C. M. Hall, in looking for an improved method of purifying bauxite, proposes to use an electric furnace where the bauxite is fused and aluminium is added to reduce the impurities, which then sink to the bottom of the molten bath in the elementary state, leaving the bauxite pure.

Another detail of great importance and no little expense in the manufacture of aluminium is the carbon electrodes. Here again the influence of cheap power is important, for Mr. Hall has developed a method of baking carbons in an electric furnace. The process has been described in his patents (see our Vol. I., pp. 30 and 467), and briefly consists in moulding the carbon electrodes from a mixture of carbon powder and pitch, then placing the articles in a furnace around a central carbon resistor, through which the current is passed. The heat thus generated in the resistor is conducted to the surrounding carbon electrodes, and they are raised to a higher temperature than can be economically obtained in an ordinary furnace using fuel. In this way an important advantage is gained, since the electrical conductivity of carbon and its resistance to oxidation are functions of the temperature to which it has been raised.

CARBORUNDUM AND ALUNDUM.

In passing over to carborundum Mr. FitzGerald gave a review of Mr. Acheson's work and pointed out how the large scale operation, beginning at Niagara Falls with a 750-kw furnace, permitted the cheaper production of carborundum, so that it could be put on the market at a price somewhat near to that of other abrasives.

At first the production of carborundum had little effect on the abrasives market, this being due in part to the costly experimental work necessary before the new material could be put into marketable form and in part to its price as compared with other abrasive materials, such as emery. Finally, however, the manufacturing difficulties were overcome and the consumer learned of the advantages of carborundum. The important growth of the carborundum industry is illustrated by the figures showing the annual production for the last fourteen years.

The production in 1891 and 1892 combined was ½ ton; 595 tons in 1896, and 2380 tons in 1903. The carborundum plant has recently been increased in size by the addition of another unit of 1500-kw capacity, so the future annual production may be estimated at 3970 tons.

Keeping in mind that carborundum must do quicker work and more work in order to compete successfully with other abrasive materials, the large production of recent years must have had a profound effect on the market for materials like emery, and thus the struggle for existence among abrasive materials has become more severe. The severity of the competition has undoubtedly resulted in a general improvement in manufactured abrasives, but in addition to this it has stimulated the development in this country of the industrial manufacture of other artificial abrasives.

Until the advent of carborundum, the hardest abrasive known, with the exception of the diamond, was corundum. But the corundum deposits were not very large and were difficult to work, and so it was that in Europe the manufacture of artificial corundum by fusing bauxite in the electric furnace developed. This manufacture was not developed in America until the competition of carborundum was felt. Now, however, artificial corundum is manufactured on a large scale at Niagara Falls by the Norton Emery Wheel Co. (see our Vol. I., p. 15), and put on the market under the name of "alundum." Mr. FitzGerald mentioned here that another artificial abrasive called "adamite" is also used in this country. It may be described as an artificial emery.

In preparing carborundum for the market it is crushed, and this results in the formation of a large quantity of powder, far more than is demanded in the abrasive trade. It was found that this powder might be used in the manufacture of steel as a substitute for ferrosilicon. The commercial material contains about 62 per cent of silicon, and this is much higher than can be obtained in blast furnace ferrosilicon. In this way a market for carborundum powders was opened, and probably a good market until the arrival of electric-furnace ferrosilicons. These are now manufactured so cheaply that it is improbable that the market for carborundum is at all as good as it was, for carborundum has the disadvantage of containing about 30 per cent of carbon. A probable effect of this new condition will be the development of the manufacture of ferrosilicons, using carborundum as a raw material, since it requires a large amount of energy to reduce silica and form high-grade ferrosilicon, so that it may be found more economical to start with carborundum instead of silica.

At a lower temperature than that of the formation of carborundum, an amorphous substance is formed. This has the same composition as carborundum, but is not crystalline, and was first described by Schützenberger, who made it in a wind-furnace from a mixture of silicon and carbon. Amorphous silicon carbide is formed in the carborundum furnace outside the crystalline zone. As might be expected, it is a very refractory material, for as the temperature is raised beyond that of the temperature of its formation, it does not fuse, but is simply converted into carborundum. This by-product of the carborundum furnace has recently been put on the market under the name of "carborundum fire sand," and forms a very good refractory under certain conditions. It is not suitable, however, for cases in which a powerfully oxidizing flame is used, since in this case the carbon is oxidized to carbon monoxide and the silicon to silica.

ARTIFICIAL GRAPHITE.

Mr. FitzGerald discussed the growth of the artificial graphite industry. It was first mainly used for electrodes in electrolytic cells, and this use is still increasing. More recently the manufacture of artificial graphite for other purposes, such as paint, dry batteries, stove polish, lubricants, etc., has assumed large dimensions. The fact that carbon articles which have been converted into graphite are so far changed in physical structure that they can be readily machined, while their resistance to oxidation is increased and their electrical resistivity decreased, makes them a very useful article in the construction

of electric furnace terminals and for other purposes in electrical engineering.

The growth of the manufacture of artificial graphite was shown by Mr. FitzGerald by the following figures: In 1897 the production of graphite amounted to 81 tons, in 1900 it was 440 tons, and in 1904 it was 1333 tons; but the sales of graphite last year amounted to 1624 tons, so that an increase of the plant has become necessary. For this purpose the International Acheson Graphite Co. is installing a 1500-kw unit, which will give an output of 2666 tons of graphite per year.

Calcium Carbide and Acetylene.

Mr. FitzGerald briefly pointed out that since the validity of the Willson patents has not been seriously attacked, the manufacture of calcium carbide is not exposed to competition in this country. This is quite different from the situation abroad. On the other hand, in the use of calcium carbide the competition is severe, if we may judge by the number of factories making acetylene generators of various types and from the voluminous patent literature dealing with the subject. Mr. FitzGerald gives some interesting notes on a factory at Niagara Falls which has recently started, or is about to start, on the preparation of calcium carbide in a special form for use in acetylene generators. The factory is owned by the Acetyvone Manufacturing Co., and will turn out carbide in the form of sticks or blocks of a certain size. These are made by grinding the carbide to powder, mixing with a suitable binding agent and then moulding the mixture in the desired form. Mr. FitzGerald exhibited some specimens of acetyvone.

The advantages of this form of calcium carbide are that it can be exposed to moist air and handled without suffering appreciable decomposition; it can be caused to give off gas with great regularity when used in a suitable generator, and when the generation of gas is to be stopped, this can be done practically instantaneously.

The generator used with this form of carbide is simple, consisting of a water reservoir, a cylinder, which acts as a reservoir for the gas, and the holder for the carbide stick. The holder is movable and connected with a small lever, which lowers the carbide stick so that it comes in contact with the surface of the water and at the same time opens the gas pipe. The acetylene gas then passes into the reservoir and through the pipe to the burner. When the lever is lowered the gas pipe is closed and the carbide stick raised out of the water, when the generation of gas stops almost instantly.

Ferro-Alloys.

The fact that Europe is a long way ahead of this country in the production of ferro-alloys by electric furnace methods was shown by Mr. FitzGerald to be due to curious circumstances. The great boom in calcium carbide in Europe about ten years ago resulted in the erection of an astonishing number of plants and in great overproduction. Then followed the celebrated Bullier patent suit, which ended, so far as France was concerned, in the establishment of the validity of the Bullier patent. This resulted in many of the calcium carbide factories stopping the manufacture of that material. The manufacture of ferro-alloys was then taken up, and later on the manufacturers turned to the production of steel in the electric furnace.

This brings out clearly the important influence of environment on the evolution of industries, for in spite of the pioneer work of the Cowles brothers, between 1880 and 1890, little advance has been made here in this particular respect. Some years ago there was a plant at Niagara Falls, manufacturing ferro-chrome, but this was burnt down, and the manufacturers sought a more favorable environment, because, in spite of the great power development at Niagara Falls, the cost of power is still very high compared with prices elsewhere, especially compared with European plants.

Recently at Niagara Falls, Messrs. Becket and Saunders have done some excellent work at the Niagara Research Laboratories on ferro-alloys. Mr. FitzGerald exhibited some specimens of ferro-alloys made at these laboratories (analyses of some specimens of alloys made by this company were given on page 133 of our April issue).

Vanillin.

In passing over to this subject Mr. FitzGerald remarked that a great deal of work has been done on the use of the electric discharge for bringing about various reactions, one of the most interesting being the oxidation of nitrogen. This problem, in spite of much study, does not as yet seem to have resulted in the development of a satisfactory commercial process for the manufacture of nitric acid from the air. The general result of the researches seems to show that the two important conditions of the reaction are temperature and pressure. In his discourse on "Vitrified Quartz" at the Royal Institution, March 8, 1901, Mr. Shenstone said: "It is interesting to record the fact, first observed by Mr. Lacell, that nitric peroxide may be produced by heating a mixture of oxygen and nitrogen above the melting point of platinum in tubes of silica."

Another interesting reference of Mr. FitzGerald related to the "Proceedings of the Royal Society," Vol. 60, where there is a paper by FitzGerald and Wilson, read December 17, 1896, on the temperature of the electric arc. The arc was formed inside a closed vessel so that its behavior under high pressure could be observed. The authors say: "We found that at any rate some of the radiation, and possibly a great deal of it, was cut off by the formation of what appeared to be red fumes of NO_2. We found no absorption from this cause so long as the pressure was nearly atmospheric, but at about 100 pounds pressure this gas was formed with great rapidity. We easily confirmed our belief in the presence of this gas by its well-known absorption spectrum.

"Lest heat dissociation might cause an apparent increase in the amount of NO_2, we tried heating some of the gas in a flask. We observed that when hot the brown fumes became a golden yellow, and the absorption bands nearly disappeared; so that the heating could not have been the cause of the apparently enormous production of NO_2 at high pressure."

It seems probable that if a commercial process of making nitric acid from the air is eventually worked out it will depend upon the combined effects of high temperature and pressure. In this connection Mr. FitzGerald called attention to a description in the *Gazzeta* for April 3, by Mr. E. Rossi, of an apparatus in which nitric oxide is formed by heating oxygen and nitrogen under high pressure with a heating resistor similar to the glower in a Nernst lamp.

However, if the use of electricity for the synthesis of oxides of nitrogen has not yet reached the industrial stage, the production of ozone for commercial purposes certainly has. This is illustrated in Niagara Falls at the works of the Ozone-Vanillin Co., which manufacture vanillin. The raw material, oil of cloves, contains a high percentage of eugenol, and this is readily converted into the isomeric compound iso-eugenol, which in turn is transformed to vanillin by oxidation.

At the works of the Ozone-Vanillin Co. the oxidation of the iso-eugenol is accomplished by means of ozonized air. For this purpose high-tension step-up transformers are used, and the ozonized air produced in the usual way by means of the silent discharge. The advantage of using a process of this kind for oxidizing purposes is obvious, avoiding, as it does, troublesome chromium or manganese residues.

Chlorine and Caustic Alkalies.

The first chlorine and caustic soda factory was that of the Castner Electrolytic Alkali Co., which owns the Castner patents and now uses 700 hp. Mr. FitzGerald remarked that there is no process he knows of which turns out a purer form of caustic soda than that working with the Castner cell, and for most analytical work it is preferable to the caustic soda specially prepared for that purpose.

In the Acker process fused sodium chloride is electrolyzed. In the Roberts Chemical Co's process a solution of potassium chloride is electrolyzed with the production of caustic potash and chlorine. The most interesting fact, however, in connection with the two last named companies is that the struggle for commercial existence has had a very stimulating effect on the development of new uses of electrolytic chlorine, since the manufacture of bleaching powder is no longer very remunerative on account of overproduction. Thus, Mr. Charles E. Acker, of the Acker Process Company, has worked out processes for the manufacture of carbon tetrachloride, tin tetrachloride and tin oxide. At the Roberts Chemical Co's works the hydrogen and chloride from the cells are combined to form hydrochloric acid. (In connection with this the two articles by Dr. F. Winteler and Dr. O. Nagel, in our Vol. II., p. 339, and Vol. III., p. 16, should be of interest.)

"OXONE."

An interesting use of caustic soda at Niagara Falls is for the production of sodium. The process used was developed by Mr. H. Y. Castner, and is carried on at the works of the Niagara Electrochemical Co. This industry has grown considerably, and gives promise of extensive growth in the future through the development of certain important derivatives recently made by the Roessler & Hasslacher Chemical Co.

An important compound made from metallic sodium is sodium peroxide. Dr. Hans Foersterling and Mr. Herbert Philipp conceived the idea of fusing sodium peroxide in any desired form, so that the solid cakes of this material might be used as generators of oxygen, much as calcium carbide is used for the generation of acetylene. This was found to be practicable, and Mr. G. F. Brindley, of the Niagara Electrochemical Co., worked out a process for the commercial manufacture of "oxone," as the new material is called.

Mr. FitzGerald exhibited several specimens of oxone. These were in the form of square blocks, weighing 70 grams each, and were specially made for generating oxygen in stereopticon work. According to Dr. Foersterling, it is the intention of the Roessler & Hasslacher Co. to manufacture also a round cake weighing about 180 grams. When one of these cakes is put into water, pure oxygen is immediately generated, 1 pound of oxone yielding 59 litres, or 2.08 cubic feet of gas. If the oxone is used in an ordinary gas generator, such as those made for laboratory purposes, oxygen gas is generated in a very convenient way. Oxone seems to be remarkably stable when exposed to air under ordinary conditions. Thus, according to Dr. Foersterling, in a test in which a cake of oxone, weighing 178 grams was exposed in the open air on a glass dish, the consumption of the oxone was at the rate of 0.618 grams per hour which corresponds to an hourly generation of 90 cubic centimeters of oxygen.

On account of the absorption of carbon dioxide by the sodium hydrate formed on the decomposition of sodium peroxide, it is proposed to use oxone for supplying oxygen and absorbing carbon dioxide in cases such as arise in the problem of supplying oxygen and absorbing carbon dioxide in submarine boats. While sodium peroxide in the ordinary form might be used for this purpose it would not be so satisfactory on account of its relative instability.

In addition to oxone the Roessler & Hasslacher Chemical Co. is now manufacturing an interesting series of peroxides, specimens of which were exhibited. Calcium peroxide, as manufactured, contains from 60 to 65 per cent of CaO_2. It is insoluble in water, but liberates oxygen in the presence of moist organic matter or by heating. It is proposed to use calcium peroxide for the sterilization and preservation of foods, since its presence would have no harmful physiological actions. It may also be used for ageing spirits and wines. Finally, it may be used in therapeutics for various purposes.

Magnesium peroxide contains from 25 to 32 per cent of MgO_2, and may be used in a similar manner to calcium peroxide. It may be employed also for sterilizing water. Thus, according to Dr. R. von Foregger, a tablet containing 0.1 gram of magnesium peroxide and 0.5 gram of citric acid dissolves readily in a litre of water and completely sterilizes it in a few minutes.

Zinc peroxide contains from 50 to 60 per cent ZnO_2. It may be used as an antiseptic dressing. Sodium perborate contains 100 per cent of $NaBO_3 + 4H_2O$. This salt, when dissolved in water, forms hydrogen peroxide, and Dr. Foregger has been able to make a 50-volume solution of hydrogen peroxide in this way. The great advantage of using a substance of this kind for bleaching purposes is obvious.

Mr. FitzGerald concluded his address by pointing out how all these electrochemical industries at Niagara Falls have been greatly stimulated by the struggle for existence and the influence of environment, and how these industries give strong evidence of vitality in the continuous adjustment of internal to external relations.

The Development and Present Status of Cyanidation in the United States.

BY WILLIAM H. DAVIS.

The cyanide process is one of the greatest achievements ever realized in the metallurgy of gold. Its influence has been felt in almost every mining region of the world. Its material addition to the world's wealth has been instructive, beneficial and stimulating to a large number of other industries. The process has, like other chemical operations, a large number of points of nicety; some have been developed and others have not, and in some respects the process is still in an unfinished state. Undoubtedly lower costs will be realized in ore treatment and a higher percentage of values extracted, but sufficient results have been realized at this time to place the process far in advance of all competitors in matters of cost of operation and bullion production.

HISTORICAL.

As early as 1867 a patent was issued to J. H. Rae, covering a proposed process for the extraction of gold and silver from their ores by the use of potassium cyanide to be aided by the use of the electric current which was to simultaneously precipitate the gold and silver upon a copper plate. Other patents were issued in 1880 and 1881, but no commercial success was achieved by these attempts. In 1885 a United States patent was obtained by J. W. Simpson, the proposed scheme being to use a solution containing 3 per cent potassium cyanide and 0.2 per cent ammonium carbonate. This treatment was set forth for ores carrying gold, silver and copper. It is not recorded that working tests were ever made, though experimental work was done, and in fact is still being done along this line. United States patents were applied for and finally granted to Messrs. MacArthur and Forrest in the year 1889, some two years after the issuance of patent by the government of Great Britain. These patents called for the use of a dilute solution of potassium cyanide, and without any other chemically active agent. While the process was anticipated before the issuance of these patents, and although other reagents were used from almost the beginning of the work, namely, alkali, still this was the dawn of the new era in gold metallurgy, and modern practice depends upon the general principles promulgated by MacArthur and Forrest.

The process was introduced into this country, as a working method, soon after the American patents were allowed, by the agents of the Cassel Gold Extraction Company, and was in some respects, pertaining to the recovery of the zinc box products, a very immature method. This was, however, soon overcome and we find the first applications being made in the years 1891 and 1892. The first successful cyanide plant to be operated in the United States was in the year 1892, and was erected and operated by Mr. Alonzo Coan in Boulder County,

Col., for the Livingston mine. The experimental tests were made during the latter part of 1891 in the city of Boulder, and the following spring work was inaugurated on the mill. This mill was operated for the greater part of ten years by this party.

A few words as to these operations will be of interest and therefore will be given. The Livingston mine lies in the telluride belt of Boulder County, and the ores therefrom are telluride ores. The ore was, however, oxidized for some distance below the surface. This natural process of roasting leaves the gold (for the values were almost wholly gold) in the so-called "rusty gold" condition, *i. e.*, with a minute layer of oxides of base metals occurring on the surface of the gold. It is presumed that the whole gold content of this ore was originally of the telluride formation. This ore was treated to the depth of 120 feet. At this depth live (telluride) ores were encountered and the farther cyaniding of the ores would require roasting. At this time the property passed into other hands. The operations of this mill comprised crushing the ore dry, with rolls to 12 mesh, then loading into vats, a five-day treatment with cyanide solution of 0.25 per cent strength, principally maceration, then washing. The average value of this ore is given me as approximately $10.00 per ton (though some ore of $4.00 value was treated at a profit); the average value of the discharged tailings were $0.80, which gives the extraction as 92.00 per cent. This plant treated 10 tons of ore per day, and was in every respect a successful plant.

Following these operations comes the great Mercur plant which treats, when in full operation, over 1000 tons per day, and is the largest dry crushing plant in the world. From this time new plants came into existence so rapidly that no attempt is made at this time to enumerate them. In fact cyanidation is so well established, so successful, so fruitful that frequently stock jobbing schemes are floated where there is no ore to treat.

Crushing.

There are two general methods of reducing the ore to the required fineness in vogue in this country, one dry by breakers and rolls, the other wet and usually (though perhaps not wisely, since better methods are now practicable) by the stamp, followed first by concentration, and last by cyanidation where sufficient values are present in the tailings to warrant the additional expense. Where the ore is to be treated as a whole by either cyanidation or chlorination, the first method is used, but where pyrite is contained in greater amounts than, say, 3 per cent (depending upon conditions of the gold), wet crushing is usually employed, followed by concentration as above stated. The American practice has been to ship the concentrates to smelters. The tailings are, for the greater part, treated by cyanide for the reason that few concentration mills make quantitative separation of the values from the quartz. There are some objections to the day crushing method from the amount of slimes or dust made, although this seldom amounts to more than 2 per cent of the total ore crushed, and in well regulated mills much below this. Dust losses, whatever they may be, are insignificant, when compared to the slime losses with wet crushing, especially when the stamp is used, as in this case the slime seldom falls below 10 per cent, and often exceeds 40 per cent. However, this matter of slimes has received special treatment and will be discussed later.

The secret of crushing dry ore with the least amount of slimes or dust is frequent and thorough screening. For this purpose the vibratory or impact screen offers advantages over the trommel type for the reasons that the smaller particles seem to adhere to the larger ones, which attraction is broken by the impact, by the momentum being added to gravitation. By this method a better separation is effected, and American practice tends toward the impact screen. In wet crushing this result could be realized through the use of a greater amount of water; but this is objectionable when concentration is employed, as a large amount of water intercepts efficient results. The proper size for crushing is usually determined by sizing the product before and after treatment, assaying separately the different sizes and plotting curves for the values and extraction.

Alkalinity.

This important topic received but little consideration from the early workers and some indifference is manifest to-day, but this is fast dying and the matter is becoming a considered factor in the economic treatment of ores by the cyanide process. Perhaps no part of the process is of such vital importance to successful work as this one. That a protective alkalinity should be maintained is a matter that will appeal to the chemist upon first consideration. He has only to remember the low acidity of hydrocyanic acid, and therefore the ready displacement by even the carbonic acid radical, which is ever present, to suggest the necessity of free alkali to retard this action. Other reasons would follow with experience, namely, the action of the double salt for which the compound KCy has great tendency. In actual work, with cyanide solutions applied to ores, perhaps the first avenue of escape is the double salt formation which, being soluble in excess of free alkali, calls for protective action.

To the physical chemist the matter of hydrolysis becomes important, which also calls for protective alkalinity, for, according to the present theory of solutions, there is always a fixed relation between the ions and the undissociated portion of the solution. Therefore, if a compound, having in common an ion with the first, be added, the dissociation of the compound is driven back. Now as there is in common between the alkaline cyanides and free alkali, the alkali radical this would prevent, at least to some extent, the dissociation of the cyanide compound which is fatal to the economic use of the process. As evidence of this it has been observed by the writer that the odor of cyanide from solutions (which is hydrocyanic acid) is much more pronounced when no free alkali is present. Without doubt the ingredients of the ore treated would have a marked effect upon this, but still the relative difference would be present.

Selection of Alkali.

In practice I have found the use of lime to have advantages over that of the more caustic alkalies. The latter tend to foul the solutions, thereby decreasing the solvent power of the solution for values sought. There are other reasons, though obscure to the writer, which are illustrated by the following experiment: Make a solution of c. p. cyanide to 0.25 per cent strength, divide into three parts. To one add a little caustic soda, to the second a corresponding amount of lime and use the third without the addition of any alkali. Now treat the same weight of gold separately by the three solutions—other conditions being the same. Finally remove the gold, wash same and evaporate the total solutions and assay, when it will be found that the solution having the alkalinity due to lime has dissolved a much greater amount than either of the remaining two. These results have been verified by the writer on a large scale.

Treatment of Coarse Sands.

The general treatment of coarse sands in this country remains practically the same as it was when the process was introduced and as it was established in South Africa. The treatment of telluride and oxidized ores consists in dry crushing, followed by roasting when necessary, and then the usual treatment, which is leaching the ore without agitation. The dust resulting from dry crushing has offered some difficulties. It was formally added to the ore before roasting with the hope of remixing and final treatment as a whole. This, however, has not proven successful, and later practice has been to treat the dust by special methods which will be considered later. When wet crushing is followed there must in every case be

used some method of sizing. This is accomplished either by the spitzkasten or overflowing a filling vat where the coarse sands are allowed to settle. When the vat is loaded the surplus water is drained off and the moisture left in the ore displaced by one of the mill solutions, the treatment being continued usually by the strong solution, then weak and this is followed by wash water.

The solution schedule of different workers varies somewhat, but the general practice is to load into strong solution when possible, macerate for a short time, 6 to 24 hours, then leach with the solutions until the ore is finished. As diffusion plays an important part, when changing solutions, it is customary to leach the offgoing solution below the surface of the ore before application of the changed strength of solution.

The time of treatment varies from 4 to 15 days, depending upon the physical condition of the values and the character of the ore. From my experience with several cyanide plants, operating upon as many types of ore, ranging from complete oxidized surface ores to the treatment of tailings from stamp mills, working upon pyritic ore, including live telluride ores which were roasted—I must say, it appears to me that not sufficient time is given in general practice for the greatest returns. For example, take a cyanide plant which, we will say, is treating 100 tons per day, the time of treatment being 8 days. The cost of cyaniding *per se* in this plant should not exceed $0.55 to $0.60 per ton on the average ore. This cost is made up, for the greater part, from consumption of chemicals, labor, power, superintendence, assaying, taxes, insurance and interest on the original investment. Now suppose the time of treatment was to be extended "N" days, what would follow? We would have practically no greater consumption of chemicals, for this occurs in the first few hours; the labor item would not be necessarily increased; all fixed charges would be the same, but N tanks must be added and the investment increased by that amount which would raise the taxes, interest and insurance. In the above case let N equal 4, then the increased cost per ton should not exceed approximately $0.10, and the increased extraction would be in excess of this amount. I predict that if this matter was properly determined (which may readily be done by the ordinate method) the average extraction would be near 90 per cent.

SLIMES TREATMENT.

In reducing ore to the required fineness, an appreciable amount of fines are always made. In dry crushing some of these fines are lost as dust. There is, however, at present in well-governed mills little or no loss during the crushing of the ore, as efficient dust collectors are on the market, which not only collect the dust made by the rolls, screens, etc., but will deliver the same, continuously and in a manner suitable for the work. The initial efforts were to reincorporate this with the coarser sands, but such practice has not been all that could be desired, and at present this part of the ore receives special treatment.

The filter-press treatment is considered both burdensome and expensive, and has not found much favor in this country. A modification of the filter-press method, making use also of decantation, has been in use for the past year at the plant of the Dorcas Reduction Company, at Florence, Col., and is described by the management as follows. Four large 70-ton agitation tanks, 13 feet 6 inches by 20 feet high with conical bottoms, are used. Into one of these tanks from 10 to 12 tons of dust are charged, solution sufficient to make a thin fluid is added, and then the whole mass is agitated with compressed air from the lower part of the bottom until the extraction is complete. The air simply is then discontinued and the charge allowed to settle for some time. The liquor is then decanted off through a vacuum pan 20 feet by 5 feet 6 inches high, the same pan being subsequently used for washing and finally for draining the slimes. The washing is extended only to a point necessary to maintain the volume of solution. The cyanide losses are given as being about 2 pounds per ton of dry slimes treated and the extraction as 93.50 per cent. This treatment is made on the dust without roasting, the dust coming from the telluride ores of Cripple Creek district. The total time of treatment is stated to be five days over all. These operations are worthy of special notice for the reason that, a hitherto considered stable compound (telluride of gold) toward cyanide solutions is brought within the field of commercial possibilities. The method is said to be simple and effectual.

In 1903 a process was set forth by Mr. George Moore, then at the Mercur plant in Utah, for the treatment of slimes. The process is a departure from both the filter-press and decantation methods. He uses a light framework, some 20 feet long, 4 feet high, and of sufficient width to permit the passage of pipes inside the framework to evacuate the filtered solutions (which is done with vacuum pump). The frames are covered with canvas, and several are grouped together, securely suspended from a traveling crane under which are arranged three tanks: one to contain the slimes which are agitated by compressed air to aid extraction, also to prevent settling. After the extraction is complete the filters are lowered into the slimes and a vacuum is created within the filters to aid

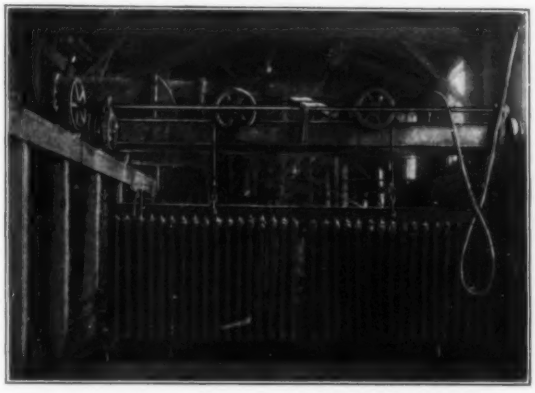


FIG. 1.—FILTER FRAMES, MOORE SLIMES PROCESS.

the filtering of the solution. The same is continued until the slime prevents further filtration, when, with vacuum maintained, the filters are raised and carried to the second tank in which a dilute solution is contained.

Here the filters are lowered and the strong solution displaced, the same followed with wash water. Finally the filters are carried to a fourth position, where the vacuum is released, and compressed air is then used to free the canvas from the slimes, the latter falling into cars for removal from the plant.

The process has been described by the inventor in the *Mining Reporter* of November 12, 1903. The first successful application of this process, so far as I am informed, was made at the Lundberg, Dorr & Wilson mill at Terry, S. D., after some modifications were made by Mr. Dorr. In a recent communication to the writer, Mr. Dorr gives a résumé of their experience with the process and such costs of operations as are available. He states: This process has now been in use a little over a year, during which time many changes and improvements have been made, and the difficulties incidental to the working out of a new process overcome. The plant has been described in Bulletin No. 7, of the South Dakota School of Mines, and in the transactions of the Black Hills Mining Men's Association. The changes made consist in an alteration in the hydraulic cranes, whereby the plates are carried from four points of support instead of one, the remodeling of the frames, and the arrangement for discharge by means of water instead of air, which gives perfect discharge, and in many other small details.

As there have been so many changes and periods when,

owing to experimentation, the process was not worked to advantage, it is difficult to give correct operating costs, but some figures can be given.

Labor.—On the night shift the process is operated by the solution man, who, in addition attends to the regular duties of the mill, such as looking after the classification of the ores, packing the zinc boxes when necessary, drying and grinding all mine and mill samples, so that it is difficult to tell how much of his time to charge to the process. On the day shift, owing to some defects in our installation that would be difficult to remedy, a slime man is employed, who, with the solution man, handles the slimes from both shifts. With arrangements for sluicing out, and a good installation, the solution man could readily handle the process on both shifts, as the work will not exceed that in a dectantation plant of like capacity.

Repairs.—The repair cost on all pumps connected with the process amounted to $0.0146 per ton of slimes treated, for an extended period of time, and may be taken as an average for this installation. It may also be considered as a maximum, since our air pumps, which have caused the major part of the repairs, are a cheap type that is not satisfactory. The total costs would remain the same if the capacity of the plant was doubled.

Renewals.—The life of the frames should be almost indefinite, as they are made of wood and pipe and are subjected to no wear. It is impossible to say what the life of the canvas will be. The original bags lasted eight months under very hard usage. The cost for renewal here was 2 cents per ton of slimes treated. The ones in present use should materially exceed the life of the original ones.

Power.—We have not been able to make satisfactory measurements of the power required, but calculating from the work done and allowing liberally for losses in the pumps, it would not exceed 4 horse-power for both the agitation necessary, and for the Moore process. This at 40 cents per horse-power day would equal 5.3 cents per ton. This cost would not increase proportionally with an increased tonnage, as the vacuum pump used is much larger than required, and the cost of keeping the slimes in suspension in the loaded vat would be about the same with a larger vat, or with two sets of plates used in that vat.

Chemicals Used.—The consumption of cyanide at the mill is about 11.7 cents per ton of ore, which is slightly under the average consumption at dry crushing plants in the district operating on similar areas, so we can assume that the loss due to the Moore process is very slight. Tests have shown practically no consumption of cyanide from the agitation with air, and losses in the discharged tailings will not exceed 0.15 pound per ton.

Extraction.—The Moore process is only intended to recover the dissolved values with the slimes, but in this plant, owing to unexpected difficulty encountered in dissolving the last of the gold in the slimes, it has had to do a part of the dissolving as well. There has been a period when precipitation was bad, and changes were made in the plant that interfered with getting the best results. For a period of about eight months the average loss in dissolved gold has been 8 cents per ton in handling $8.00 slimes, and during this period the gold dissolved during the passage of the slimes through the Moore process has averaged $0.32. This fact and an inspection of the daily record which shows considerable losses due to causes that can be avoided, explains most of that loss. The following results from a 15-day consecutive run will show the possibilities of the process.

Valuation of the slimes entering the process (laboratory washed)	$1.154
Valuation of the discharged slimes	$0.984
Valuation of the discharged slimes (laboratory washed)	$0.970
Tailings cyanided again in the laboratory (discharge)	$0.956

Fig. 1 (p. 257) shows the general construction of the Moore process as applied at the Lundberg, Dorr & Wilson plant.

The decantation method has, perhaps, found more followers in the United States than other methods, and from the simplicity of the method it would seem that it was the better method where no talc is contained in the ore. But where talc is contained and where the ore makes a considerable amount of extremely fine slime, the decantation method becomes too slow. There have been a great number of schemes promulgated for the treatment of slimes, but none have become commercial factors and, therefore, will not be mentioned here.

Treatment of High-Grade Ores.

The cyanide process has been regarded as appropriate for the treatment of low-grade ores only. This conception has come from the early use of the process, the original application being made to tailings. This would intimate a limitation as to value of ore which could be economically treated. Simple logic, together with acquaintance with a few facts, should be all required to clear this question. Thus, if all the gold contained in a unit weight of ore was in one particle, then it would follow that the size of this particle would increase with increasing values of the ore, but this is not true—commercially, at least. We are, therefore, licensed by nature to assume that with increasing values an increasing number of particles ensue. This premise is enforced by fine crushing.

Now if it takes T time to dissolve one particle of gold in position P in the ore, other things being equal, it would require no greater time to dissolve another particle in position P_2. In fact, this would be true if the number were extended to P_n—where n is less than infinity. This is not intended to mean that coarse gold is not present in ores of higher values—this may or may not be true, since coarse values are peculiar more to types of ore rather than to grade. We see, therefore, that there is no *a priori* reason why ores of any value should not be successfully treated by the cyanide process where the ores are amenable to any chemical process.

Let us now look to general practice. The Dorcas Reduction Works is a custom mill, treating Cripple Creek ore, which is purchased upon full assay value and paid for. It is then crushed, roasted and cyanided. The average value of the ore treated during the past three years is given me by the management as being $35.00 per ton, and frequently for months as high as $60.00, the highest average for a single month being $86.02. These values are above the average treated by other chemical mills working on the same ores. The average extraction for the greater values is given as being from 95.00 to 96.50 per cent, while for the lower grades assaying approximately $25.00 per ton it is between 93.50 and 94.50 per cent, which means that the unavailable gold in the higher grade ore is not greater, practically, than in the lower grade, and confirms the above conclusions. This plant treats normally 125 tons per 24 hours, and has been in operation for some four years.

Precipitation.

In the American practice of precipitation the zinc shavings method has found the greatest number of followers. Perhaps one reason is that this was the method introduced with the process, but a much more important reason is that efficient results attend the use of this method. In general, about 1 pound of shavings, costing $0.12, ready for the mill, will precipitate 1 ounce of gold, while in the electrolytic method of precipitation the cost of the energy necessary to precipitate this amount of gold would be theoretically much below this (assuming 100.00 per cent efficiency for electrolysis, about 65 watt-hours per ounce). Still, in American practice the electrolytic precipitation has not found favor, and it is difficult to obtain reliable data. It is, however, the general belief that the zinc method is the cheaper method, and this is in all probability true. The objection usually met with is the anode action and the excessive alkalinity required for complete precipitation.

It is doubtful that the electrolytic method will ever displace the zinc method in this country.

CLEAN-UP AND REFINING.

With the zinc method the clean-up consists in the removal of all the zinc from the boxes and a careful washing of the same with water. This is accomplished by placing the zinc on a screen—6 to 12 mesh—and scrubbing in water. The zinc remaining on the screen is returned to the zinc box for further use, the product passing being added to the mass for reduction. This product is sufficiently washed to remove all cyanide and alkali, and is then treated with dilute sulphuric acid to separate the values from the zinc. After this action is complete, the product is washed to remove excess of acid, then dried to a pasty mass with air, either on a vacuum pan or filter press, and finally to complete dryness by heat, after which it is mixed with suitable flux and melted to bullion, the finness of which is from 850 to 975, depending upon the care with which the operation is made. The bullion is then shipped direct to the mint, and settlement is made by the government upon a basis of $20.67 per ounce of fine gold. A great many special methods have been and are in use for both precipitation and refining. In precipitation the zinc dust method offers some attractions. The zinc consumption is perhaps less than with the shavings method. But the dust costs more than the shavings, and filter presses are necessary, also compressed air for agitation of the solution, which is run into tanks with conical bottoms. This solution is segregated and zinc dust is added, and then the whole mass is agitated with air, afterwards decanted and run through a filter press and returned to the general stock. The method seems more applicable to large plants as more attendance is required. In small plants the greater cost would overbalance the gain in zinc savings. The product may be refined in the usual manner by the use of acid, or the excess of zinc may be removed by lead acetate, sufficient lead added and the mass cupelled, which yields a high-grade bullion, but calls for a special furnace.

A special method of refining, which, when properly conducted, will give an exceedingly high-grade bullion—from 990 to 997 fine—was patented in 1894 by Messrs. Alonzo Coan and Hugh F. Watts, the procedure for which Mr. Watts describes as follows: Treat the zinc first with dilute sulphuric acid in the same manner as the general treatment, wash and dry to about 10 per cent moisture, then digest with concentrated sulphuric acid, heating the same for from thirty minutes to one hour in cast-iron vessel, the acid to be used only in slight excess. After the action is over the mass is cooled and diluted, then allowed to settle. The values subside very quickly to a perfectly clear solution, after which decantation may be used in washing, and in this way a thorough washing perfected, which is followed by drying and melting in the usual manner. It will be seen from the foregoing that the silver will be attacked, and if proper conditions were present the gold and silver would be parted. The silver, however, may be recovered from the acid liquor as a chloride, melted separately or added to the gold as desired. This method is extremely simple and gives excellent results.

REGENERATION.

The regeneration of the alkaline cyanides from the double salts has received some attention in this country, and was for some time considered to be a momentous question, since, when solved, it would make possible the treatment of all ores by the process. There are at present two methods, either of which will recover, as alkaline cyanide, the cyanogen in the double salts of working solutions. While it has been found in practice that a material saving is made in the cyanide consumption it has also been realized that the value of regeneration was overestimated, and that by regeneration the treatment of all ores has not been made possible. A brief review of these methods will be given here, together with such results as are available.

The Orr Methods.—In 1901 William Orr, of the Gold & Silver Extraction Co. of America, Ltd., patented a method which has been applied to several mills, it is claimed, with marked success. This method is largely a chemical one, and is described in United States patents Nos. 687,258, 689,017 and 689,018. In general, the process consists in a segregation of a fractional part of the solution, treating the same with caustic soda to decompose the double salts, and then with sodium sulphide to remove the base metals, which is presumed to be largely zinc. If copper is present in the solution the same is removed by electrolysis before the solution is passed to the zinc boxes for precipitation of the gold values, zinc cathodes being used, whereby the cyanogen is transformed into a zinc cyanide with precipitation of the copper. The solution is then run through the zinc boxes, where the gold is removed, and the solution is then treated as above. The cyanide is recovered from the waste solutions by adding an excess of zinc chloride and precipitating the cyanide as zinc cyanide. The same is removed either by filtration or decantation and returned to the working solutions as desired; recovery being made in the above manner. The technical modus operandi has not been made public by Mr. Orr, and therefore detailed results are meager.

Davis Method.—This method of recovery of the cyanogen depends upon the use and action of an alternating electric current. The solution is treated as a whole, without segregation, which is accomplished by placing suitable electrodes in the solution storage vat, the same to contain approximately the volume, in tons, which is used in the plant per 24 hours. By this the time of threatment of the solution is 24 hours. Slacked lime is added to the solution, each time a pumping from the sump occurs, and in the same manner as the cyanide is added, *e. g.*, by placing in some receptacle and allowing the pumped solution to flow over the alkali whereby the alkali is dissolved and added to the storage solution.

FIG. 2.—CYANIDE PLANT SMUGGLER-UNION MINING CO.

The electrodes are preferably lead, as slight action occurs, although a set of lead electrodes will last but little more than half a year. They then become honeycombed and lose the metallic property of lead to some extent. The distance of the electrodes apart, is, with wooden tanks, the diameter of the tank, the object being to get equal distribution of the current throughout the whole solution mass. Therefore the electrodes should be as long as the tank is high, and from 6 inches to 1 foot wide.

A suitable transformer giving a potential sufficient to produce a current from .05 to .10 amperes per ton of solution contained in the storage tank should be used. The frequency should be 60 periods per second, and there should be no ebullition of gas at either electrode. To deliver the energy to the

solution, care should be taken that no pipe or other metallic conductor prevent this. The current should be maintained continuously and free alkali present, no mixture of alkalies used.

This process was applied, as described, to the cyanide plant of the Smuggler-Union Mining Co., (Fig. 2) about May 15, 1902, some four and one-half months after that plant was put into commission. This plant used, when in full operation, a total of some 2000 tons of solutions. Therefore some time elapsed before the solution had made its circuit and become treated. When this was done a marked difference in the KCy consumption was realized. Previous to this some 400 to 500 pounds of cyanide was necessary each day to maintain the standard strength of the solution. After the process was in full operation for two or three days, and the maximum effect reached, no cyanide was needed, then a few pounds, and finally as the double salts were regenerated and used the addition of fresh cyanide came up to a point some 25 per cent below the consumption before the process was installed. The solution in the mean time titrated as a c. p. solution with a pure opalescent end point (the Liebeg method being the one in use) and had all other indications of being purified. The results of the first four months were tabulated as being typical of the work of the plant without the process, and, neglecting May, the four following as that representing the improvement due to the process, the following are the results:

Total tons ore treated first four months was....	38,190.00
Total pounds KCy used first four months was..	42,600.00
Total KCy per ton of ore.....	1.11 lb.
Average extraction first four months was Au 58.46 per cent, Ag 33.16 per cent.	
Total tons ore treated last four months was....	49,098.00
Total pounds KCy used last four months was..	38,600.00
KCy per ton of ore was.....	0.78 lb.
Average extraction last four months was Au 75.55 per cent, Ag 37.97 per cent.	

Reduced consumption of KCy was 29.73 per cent.

Increased extraction was Au 17.09 per cent, Ag 4.81 per cent; total, 21.90 per cent.

After the process had been operated some six months, the solution was removed from the storage tank, and what was estimated to be 75 tons of precipitate was removed from the tank which contained calcium (as carbonate), also some oxide, arsenic, antimony, zinc, iron, aluminum and a trace of copper. No change in the character of the ore could be observed during the time of this comparison.

The writer is aware that these results are not akin to the present theory held by electrochemists, but after due consideration and in view of the above facts there can be but one conclusions, namely, that the theories are, at least, incomplete. Whether the action of the alternating current is a direct one on the compounds, or but a secondary, I have no means of determining.

Boulder, Col.

On Autogenous Lead Soldering.

By M. U. Schoop.

There exist at present quite a number of methods by which autogenous lead soldering (*i. e.*, welding without any flux or any foreign metal) may be performed. Of these methods, the following are of special value for storage battery factories, and are used to a greater or smaller extent:

(1) *Air-hydrogen flame;* the hydrogen is either produced from zinc and sulphuric acid, or is taken from steel bottles in which the hydrogen is compressed up to 125 atmospheres.

(2) *Oxygen-hydrogen flame;* both gases are obtained by electrolytic decomposition of water, and are used in the factory at a pressure of 500 to 600 mm. water column, while for installing batteries outside the factory, the gases are compressed in steel bottles.

(3) *Oxygen-illuminating gas flame;* according to the circumstances, this method may often be used in factories as a substitute for method (2). The heat of the flame is, however, considerably lower than in (2).

(4) *Electric resistance heating;* this method has been developed and is in use especially in French storage battery factories.

Finally soldering with the *"Pollak solder"* may be mentioned. This method makes very quick work possible, and consists in treating the heated edges with an alloy of hard lead, tin and mercury.

The use of the oxygen-hydrogen flame has such distinct advantages over the air-hydrogen method that especially in German factories the latter method has been completely replaced by the former. The two largest German works (Kölner Accumulatoren Werke and Accumulatoren Fabrik A. G., Berlin) have their own electrolytic plants for the production of oxygen and hydrogen. On the other hand, English factories use, as far as I know, exclusively the old "wet method" (zinc-sulphuric acid and air); this is somewhat astonishing, since compressed oxygen and hydrogen are probably obtainable in commerce in England.

The great disadvantage of the air-hydrogen flame, in comparison with the oxy-hydrogen flame, is mainly due to the fact that on account of the content of nitrogen in air, the economy of the burning process is very poor. In other words, much less work can be done in the same time than with the oxy-hydrogen flame with its absence of nitrogen. For large types of plates the loss of time may amount to 300 per cent; moreover, there is a great difference in the quality of the work.

Another disadvantage of the "wet method" is its dangerousness. Whoever has been working for years in storage battery factories knows that the handling of the reservoirs for developing the gas and of the air containers is by no means without danger, and I know myself several cases in which the engineer who made the installation, or his helper who has generally to attend to the apparatus, were killed; on the other hand, I do not know of a single accident with steel containers, although they have been used in the two German factories mentioned above for the last four and six years, respectively. It may sound paradoxical, but the statement is true that the use of compressed oxygen and hydrogen is absolutely dangerless, while the use of hydrogen and air is not free from danger. By the way, I may call attention to the fact that sulphuric acid, sold as technically pure, and often also raw zinc, contains arsenic, and that for this reason objections may be raised against this method, especially if the installation is made in a poorly ventilated cellar or vault, and the development of troublesome acid vapors cannot be avoided.

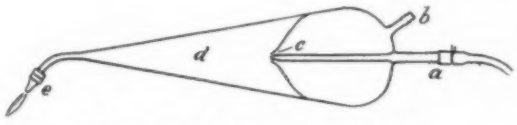


FIG. I.—BURNER FOR LARGE SCALE WORK.

I have already described in various articles the oxy-hydrogen method, as well as the commercial electrolysis of water, so that I may refer the reader to these articles.[1] To many readers, however, the following construction of a burner may be novel, the principle of which may be applied with advantage to the use of oxy-hydrogen flame, as well as to hydrogen-air flame, and which should be specially useful in the latter case. The principle of burners of this kind is that in the same the one gas sucks the other gas, so that it is impossible that one gas might pass into the supply pipe of the other gas.

Fig. 1 shows a burner for more extended work. The hydro-

[1] L'Eclairage Electrique, 1899, 16, XII.; Zeit. f. Elek., 1900, No. 37, and 1901, No. 18; Die Industrielle Elektrolyse des Wassers (Enke, Stuttgart, 1901.)

gen is supplied at *a*, and as soon as its velocity is beyond a certain minimum value, there is a sucking action at the aperture *c*, so that an explosive mixture is formed in the chamber *d*. If one wants to use the illuminating gas-oxygen flame, the oxygen is supplied under a certain pressure at *a*, and the gas hose is fastened at *b*. In both cases it is important to provide the chamber *d* for mixing the gases, since otherwise the gases have not sufficient time for intimate mixture, so that a non-homogeneous mixture passes out at *e* and the temperature of the flame is lowered.

Another form of this burner, especially suitable for work on a small scale, is shown in Fig. 2. Here the air is sucked in through the two holes in close proximity to the terminal; one of these two holes may be partly or completely closed by means

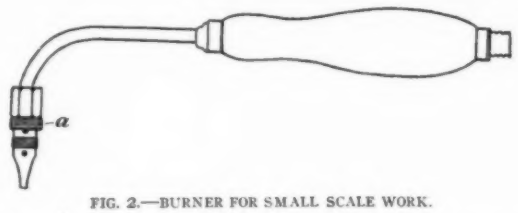


FIG. 2.—BURNER FOR SMALL SCALE WORK.

of the regulating ring *a*. This burner contains no chamber for mixing the gases, but this slight disadvantage is counterbalanced by the neatness of the instrument.

It is at once evident that this burner will render good service in all cases in which it is desired for some reason to use the air-hydrogen flame. In cases of small repairs outside of the factory it is often preferable to give the man only one small hydrogen bottle, instead of two steel bottles with oxygen and hydrogen. If the hydrogen is produced at the place of the repairs from zinc and sulphuric acid, there is no need for the otherwise necessary and dangerous air-gasometer, so that there is a saving in the cost of transport and attendance. If work is to be done in the factory itself, the use of this burner makes a compressed-air supply unnecesary.

If the electric resistance heating method is used, care must be taken that the applied voltage is not more than 14 to 18 volts, so that no arc can be formed; further, the carbon pencil is to be connected to the negative pole of the supply. If the latter point is neglected, the joint gets dirty, on account of carbon particles. The electric welding method can be completely learned by unskilled workingmen in one or two days, while the use of the air-hydrogen flame, or of the oxy-hydrogen flame requires considerable practical experence; this explains why good men for this work demand good wages.

Paris, France.

Metallurgical Calculations.—V.

BY J. W. RICHARDS, PH.D.
Professor of Metallurgy in Lehigh University.

THE THERMOCHEMISTRY OF HIGH TEMPERATURES.

(Continued.)

In order to apply the principles explained in the preceding discussion, two sets of data are necessary; first, the thermochemical data, such as are ordinarily obtained by laboratory experiments at laboratory temperatures; second, physical data concerning the specific heats and latent heats of fusion, and volatilization of elements and compounds. The first have been given, at least for all important compounds met with in metallurgy, in a previous paper (April), the latter will now be discussed and the data presented as far as they have been determined.

SPECIFIC HEATS OF THE ELEMENTS.

Dulong and Petit's law announces the fact that the specific heat of atomic weight of a solid metal is nearly constant, the value varying between 6 and 7, and averaging 6.4. This generalization was made chiefly upon the basis of the specific heats of the metals, as determined in the range 100° C. to 10° or 15° C., such as in Regnault's accurate experiments. About the only notable exceptions to this rule are carbon, boron and silicon, and it has been naively remarked by more modern physicists that these exceptions to the rule disappear if we find the specific heat of these three elements at high temperatures, that, for instance, the specific heat of carbon above 1000° C. is 0.5, making its atomic specific heat $0.5 \times 12 = 6$, and therefore the exceptions to the rule are all accounted for. Now, the rule is an important one, and has done good service, but the exceptions just noted and their behavior at high temperatures really prove that the rule must be made more general, or else abandoned altogether. The fact is, that the specific heats of almost all the solid elements increase with the tempearture at a rate equal to an increase of about 0.04 per cent of their value for each degree centigrade, so that the atomic specific heat of the majority of the elements, which is about 6.4 at ordinary temperatures, becomes about 40 per cent greater at 1000° C. for such elements as are not melted at that temperature. Therefore, while we may say that at ordinary temperatures the specific heat of atomic weight of a solid element is 6.4, and its specific heat per unit of weight is 6.4, divided by the atomic weight, yet it will be more accurate, if actual determinations have not been made, to assume that the actual specific heat increases 0.04 per cent for every degree rise in temperature, and mean specific heat to zero half that fast.

The specific heat in the liquid state has not been determined for many elements. It is in general higher than the specific heat of the solid at ordinary temperatures; in fact, it appears to be more nearly equal to the specific heat of the solid element just before fusion, and may be so assumed if no determinations have been made. It is found, furthermore, not to change perceptibly with rise of temperature, so that it may be assumed constant.

The specific heat of the gaseous elements has been determined only for those which are gaseous at low temperatures. For the metals which, as far as known, have monatomic vapors, *i. e.*, vapors in which the atoms exist alone and uncoupled with each other, the specific heat of atomic weight, occupying 22.22 cubic meters at standard conditions, should be theoretically 5.0 Calories at constant pressure, or 0.225 per cubic meter. We may thus estimate the specific heat of metallic vapors which have not been determined.

LATENT HEATS OF FUSION OF THE ELEMENTS.

The passage from the solid to the liquid state is in all cases accompanied by an absorption of heat, which in amount varies from one or two Calories up to 100 Calories per unit of weight. This quantity has been most frequently determined by finding calorimetrically how much heat is given out by unit weight of the melted element just at its setting point, in cooling to ordinary temperatures, and subtracting from this the heat in unit weight of the solid substance at the melting point, as determined most accurately by exterpolating the value of mean specific heat of the solid up to the melting point. In this manner the latent heat of fusion for a number of elements has been directly determined.

If a crucible full of melted metal is allowed to cool, the temperature falls regularly until the melting point is reached, and then stays constant, or nearly so, for some time, while the metal is setting. A comparison of the rate of cooling before and after setting, with the length of time during which the temperature was constant, gives the relative value of the latent heat of fusion in terms of the specific heat of the melted metal and of the solid metal near to the melting point.

While the latent heat of fusion per unit weight shows no perceptible regularities, it is found that as soon as the latent heat of fusion is expressed per atomic weight of the element (analogous to specific heat of atomic weight) that notable

regularities appear. The elements with high melting points have high atomic heats of fusion, and *vice versa*, so that if the elements are arranged in the order of their melting points their latent heats of fusion per atomic weight of each are in the same order, and very nearly proportionately so. If, for instance, a chart or diagram is made, using the melting points as abscissas, and latent heats of fusion of atomic weights as ordinates, the latter will lie very nearly in a straight line. Numerically, if the melting points be expressed in degrees of absolute temperature (centigrade temperatures plus 273), the latent heats of fusion of atomic weights average about 2.1 times the temperature of the melting point. This rule may be used to predict an undetermined latent heat of fusion.

In addition to the above general rule, another one bearing on the same question was also discovered and applied by the writer. (See *Journal of the Franklin Institute*, May, 1897.) According to this observation, the continued product of the latent heat of fusion of atomic weight and the coefficient of expansion and the cube root of the atomic volume (atomic weight divided by specific gravity) is a constant. If the coefficient of linear expansion between 0° and 100° C. is used, the constant is 0.095, or if the actual linear expansion of unit length from 0° to 100° C. is used, the constant is 9.5. This rule, applied to all elements whose latent heat of fusion is known, gives satisfactory agreements, and enables us therefore to predict the latent heat of fusion of nearly a dozen other elements for which the coefficient of expansion is known.

Latent Heats of Vaporization of the Elements.

This datum has been determined for but a very few elements. Some of the metalloids, like sulphur, phosphorus and arsenic, are known to become complex vapors immediately above their boiling point, corresponding to such formulæ as S^6, P^4, As^4; the metals, as far as they have been tested, pass into monatomic vapors, such as Na, K, Hg, Zn and Cd, in which each atom represents a molecule. In the latter cases the following generalization may be made: The latent heat of vaporization of atomic weight is proportional to the absolute temperatures of the boiling point at atmospheric pressure, and is numerically equal to about twenty-three times that temperature (twenty-one times, if the outer work of overcoming the atmospheric pressure be not included). From this rule it is possible to estimate the amount of heat necessary to vaporize any metal whose boiling point under atmospheric pressure is known.

Examples: The boiling point of carbon under atmospheric pressure is 3,700° C., and if its vapor is monatomic, the latent heat of vaporization is, for an atomic weight of carbon (C = 12), $23 \times (3700 + 273) = 92{,}080$ Calories, equal to 7,673 Calories per kilogram of carbon. If the vapor is diatomic, and its formula C^2, then the above latent heat is for twenty-four parts of carbon, and for one part by weight is 3,808 Calories. Other considerations, from thermochemistry, make the latter value the more probable one.

The boiling point of cadmium is 772° C., and its vapor is known to be monatomic, what is its latent heat of vaporization? The atomic weight being 112, the latent heat of vaporization of this quantity is $23 \times (772 + 273) = 24{,}035$ Calories, which is 215 Calories per kilogram.

In making such calculations it must be strictly observed that the boiling point *under atmospheric pressure* is to be used, and not any temperature at which vapors may appear at partial tensions which may be only small fractions of atmospheric pressure.

Thermo-Physics of the Elements.

Having laid down the laws and the empirical rules which appear to govern these phenomena, we will now discuss the data for the common elements, giving both what is known and what may be assumed as probably true wherever actual determinations have not been made. The elements will be taken up in the order of their atomic weights,—the only scientifically logical order.

In all cases, the actually measured *mean* specific heats, Sm, will be given. In the case of gases, these will be the mean specific heats under constant pressure; if they are desired under constant volume the amount of outer work must be calculated in Calories (two Calories per degree for a molecular weight of a gas, 0.09 Calories per degree for 1 cubic meter, and 0.09 ÷ weight of 1 cubic meter for a kilogram of gas), and subtracted from the specific heat at constant pressure. The specific heat of 1 cubic foot is, in pound Calories, the specific heat per cubic meter divided by 35.32 and multiplied by 2.204, or, in brief, multiplied by 0.0624; in British thermal units it will be nine-fifths as much, or the specific heat per cubic meter multiplied by 0.1123.

If, from the data given, it is desired to find the mean specific heat between any two temperatures, t and t', instead of the mean specific heat from t to 0°, as given directly by the formula, it need only be observed that Sm from t' to t is obtainable by finding Sm from 0° to (t' + t). If, for instance, Sm (0 to t) = 0.303 + 0.000027 t, then Sm (t to t') = 0.303 + 0.000027 (t' + t). Furthermore, if the actual specific heat at any temperature t is desired, it is equal to the mean specific heat from 0° to 2t; *e. g.*, in the above case, S (at any temperature t) = 0.303 + 0.000027 (2t) = 0.303 + 0.000054 (t).

Temperatures will be always given and represented in centigrade degrees, except where the specific heat is given in British thermal units, in which case *t* represents, of course, Farenheit degrees, and will also be printed in italics, *t*, to further distinguish it from t in centigrade degrees. Absolute temperatures, if used, will be designated as T, and are equal to t + 273.

Hydrogen.

From the experiments of Mallard and Le Chatelier we deduce:

Sm (0 — t) 1 kilogram (up to 2000° C.) = 3.700 + 0.0003t Calories.
1 pound (up to 2000° C.) = 3.700 + 0.0003t pound Calories.
1 pound (up to 3600° F.) = 6.660 + 0.0003*t* B. T. U.
1 cu. meter (up to 2000° C.) = 0.303 + 0.000027t Calories.
1 cu. foot (up to 2000° C.) = 0.0189 + 0.0000017t pound Calories.
1 cu. foot (up to 3600° F.) = 0.0341 + 0.0000171 B. T. U.

For higher temperatures, such as electric furnace heats between 2000° and 4000° C. (3600° to 7200° F.); Berthelot and Vielle have made experiments which give us:

Sm (0 — t)	1 kilogram	= 2.75 + 0.0008t Calories.
	1 pound	= 2.75 + 0.0008t pound Cal.
	1 pound	= 4.95 + 0.0008*t* B. T. U.
	1 cubic meter	= 0.2575 + 0.000072t Calories.
	1 cubic foot	= 0.0161 + 0.0000045t pound Cal.
	1 cubic foot	= 0.0290 + 0.0000045*t* B. T. U.

Lithium.

Sm (26° to 100°) (solid)	= 0.9408 (Regnault).
Melting point	= 180° C.
Latent heat of fusion (1 kilo.)	= 73 (calculated).
S (liquid)	= 0.975 (calculated).
Boiling point	= 500° (estimated).
Latent heat of vaporization	= 2,540 Cal. (calculated).
S (gas) per kilo.	= 0.714 (calculated).
per cubic meter	= 0.225 (assumed).

Beryllium.

Sm (solid) = 0.3756 + 0.00106t (Humpidge)

Boron.

Sm (solid) = 0.22 + 0.00035t (Weber).

CARBON.

Sm (amorphous) t under 250° = 0.1567 + 0.00036t.
(250° to 1000°) = 0.2142 + 0.0001166t.
(for t over 1000°) = $0.5 - \frac{120}{t}$

Sm (graphite)	= Approximately the same.
Boiling point	= 3700° C.
Latent heat of vaporization	= 23 T = 92,080 Cal. per molecule.
	= 3,837 Cal. per kilo. if vapor is C^2.
	= 6,906 B. T. U. per pound.
S (vapor) per cubic meter	= 0.27 if diatomic (assumed).
per kilogram	= 0.25 if diatomic.

NITROGEN.

Sm (o — t) 1 kilogram (up to 2000° C.) = 0.2405 + 0.0000214t Cal.
1 pound (up to 2000° C.) = 0.2405 + 0.0000214t pound Cal.
1 pound (up to 3600° F.) = 0.4329 + 0.0000214t B. T. U.
1 cu. meter (up to 2000° C.) = 0.303 + 0.000027t Cal.
1 cu. foot (up to 2000° C.) = 0.0189 + 0.0000017t pound Cal.
1 cu. foot (up to 3600° F.) = 0.0341 + 0.0000017t B. T. U.

For temperatures between 2000° and 4000° C. the following are the values of the mean specific heats to zero:

Sm (o — t) 1 kilogram	= 0.2044 + 0.000057t Cal.
1 pound	= 0.2044 + 0.000057t pound Cal.
1 pound	= 0.3679 + 0.000057t B. T. U.
1 cubic meter	= 0.2575 + 0.000072t Cal.
1 cubic foot	= 0.0161 + 0.0000045t pound Cal.
1 cubic foot	= 0.0290 + 0.0000045t B. T. U.

OXYGEN.

Sm (o — t) 1 kilogram (up to 2000° C.) = 0.2104 + 0.0000187t Cal.
1 pound (up to 2000° C.) = 0.2104 + 0.0000187t pound Cal.
1 pound (up to 3600° F.) = 0.3837 + 0.0000187t B. T. U.
1 cu. meter (up to 2000° C.) = 0.303 + 0.000027t Cal.
1 cu. foot (up to 2000° C.) = 0.0189 + 0.0000017t pound Cal.
1 cu. foot (up to 3600° F.) = 0.0341 + 0.0000017t B. T. U.
Sm (o — t) 1 cu. meter (2000° — 4000° C.) = 0.2575 + 0.000072t Cal.
1 cu. foot (2000° — 4000° C.) = 0.0161 + 0.0000045t pound Cal.
1 cu. foot (3600° — 7200° F.) = 0.0290 + 0.0000045t B. T. U.
1 kilogram (2000° — 4000° C.) = 0.1788 + 0.00005t Cal.
1 pound (2000° — 4000° C.) = 0.1788 + 0.00005t pound Cal.
1 pound (3600° — 7200° F.) = 0.3218 + 0.00005t B. T. U.

SODIUM.

Sm (solid) (— 38 to + 10° C.)	= 0.293 (Regnault).
Melting point	= 96.5° C.
Latent heat of fusion	= 31.7 Cal. (Johannis).
	= 730 Cal. per atomic weight.
S. liquid	= 0.30 (estimated).
Boiling point	= 742° C.
Latent heat of vaporization	= 23T = 23,345 Cal. per Na.
	= 1,015 Cal. per kilogram.
S of vapor per kilogram	= 0.2174 Cal. (calculated).
per pound	= 0.2174 pound Cal.
per pound	= 0.3914 B. T. U.
per cubic meter	= 0.225 Cal.
per cubic foot	= 0.014 pound Cal.
per cubic foot	= 0.0253 B. T. U.

MAGNESIUM.

Sm (solid) (22° — 98°)	= 0.25 (Regnault).
Melting point	= 750° C. (approximate).
Latent heat of fusion	= 58 Cal. (calculated).
Boiling point	= 1100° (Ditte).
Latent heat of vaporization	= 31,580 Cal. for Mg. = 24 (calculated).
	= 1,315 Cal. per kilogram.
S (vapor) per cubic meter	= 0.225 Cal. (assumed for Mg.).
per cubic foot	= 0.014 pound Cal.
per cubic foot	= 0.0253 B. T. U.
per kilogram	= 0.2084 Cal.
per pound	= 0.2084 pound Cal.
per pound	= 0.3752 B. T. U.

ALUMINIUM.

Sm (o — t) solid	= 0.2220 + 0.00005t (Richards).
Melting point	= 625°.
Heat in solid at 625°	= 158.3 Cal. (Richards).
Heat in liquid at 625°	= 258.3 Cal. (Richards).
Latent heat of fusion	= 100.0 Cal. (Richards).
S in liquid state	= 0.308 (constant up to 800°) (Pionchon).
Boiling point (estimated)	= 2300° C.
Latent heat of vaporization	= 61.480 Cal. for Al. = 27 (calculated).
	= 2.277 Cal. per kilogram.
S (vapor) per cubic meter	= 0.225 Cal.
per kilogram	= 0.1852 Cal.
per pound	= 0.3334 B. T. U.

SILICON.

Sm (o — t) (solid, up to 234° C.)	= 0.17 + 0.00009t (Weber).
Melting point	= 1430° C. (Elihu Thompson).
Latent heat of fusion	= 3,576 Cal. for Si. = 28 (Calculated).
	= 127.7 Cal. per kilogram.
Boiling point	= 2800° C. (estimated).
Latent heat of vaporization	= 70,680 Cal. for Si. = 28 (Calculated).
	= 2,524 Cal. per kilogram if vapor is Si.
	= 1,262 Cal. if vapor is Si^2.
S (vapor) per cubic meter	= 0.225 Cal. (assumed for Si.).
per cubic meter	= 0.205 Cal. (if vapor is $Si.^2$).
per kilogram	= 0.107 Cal. (if vapor is $Si.^2$).

PHOSPHORUS.

Sm (solid) (— 20 to + 7°)	= 0.1788.
Melting point	= 44°
Latent heat of fusion	= 156 Cal. for P = 31.
	= 5.03 Cal. per kilogram.
S (liquid) (44° to 51°)	= 0.2045.
Boiling point	= 287°.
Latent heat of vaporization	= 23T = 12,880 Cal. per molecule = P^4.
	= 104 Cal. per kilogram.
S (vapor) estimated	= 0.36 Cal. per cubic meter.
	= 0.064 Cal. per kilogram.
	= 0.115 B. T. U. per pound.

Sulphur.

Sm (solid) (15° to 97°)	= 0.1844 (Regnault).
Melting point	= 114° C.
Latent heat of fusion	= 9.37 Cal. (Person).
S (liquid) (119° to 147°)	= 0.2346 (Person).
Boiling point	= 444.5°.
Latent heat of vaporization	= 72 Cal. per kilogram.
	= 13,825 Cal. for S^8 = 192.
	= 130 B. T. U. per pound.
S (of vapor) per cubic meter	= 0.50 for S^8 up to 500°.
per cubic meter	= 0.315 for S^2 above 800°.

Chlorine.

Sm (constant pressure)	
1 kilogram	= 0.1241 (from 13° to 202°) (Regnault).
1 cubic meter	= 0.40 Cal. (from 13° to 202°).
1 cubic foot	= 0.025 pound Cal.
1 cubic foot	= 0.045 B. T. U.

Potassium.

Sm (solid) — 78° to + 23°	= 0.1602 (Schüz).
Melting point	= 58°.
Latent heat of fusion	= 15.7 Cal. (Johannis).
	= 612 Cal. for K = 39.
Sm (liquid) 98° to 58°	= 0.25 (Johannis).
Boiling point	= 730° (Carnelley and Williams)
Latent heat of vaporization	= 23 T = 23,069 Cal. for K = 39.
	= 592 Cal. per kilogram (calculated).
	= 1065 B. T. U. per pound.
S (vapor) per cubic meter	= 0.225 Cal. (assumed).
per cubic foot	= 0.014 pound Cal.
per cubic foot	= 0.025 B. T. U.
per kilogram	= 0.128 Cal.
per pound	= 0.230 B. T. U.

Calcium.

Sm (solid) 0° to 100°	= 0.1704 (Bunsen).
Melting point	= 780°.
Latent heat of fusion	= 2.1 T = 2,106 Cal. for Ca. = 40
	= 52.6 Cal. per kilogram.

Titanium.

Sm (solid) 0° to 400°	= 0.0978 + 0.000147t (Nilson and Pettersson).

Vanadium.

Sm (0° to 100°)	= 6.4 for V = 51 (assumed).
	= 0.125 Cal. per kilogram.

Chromium.

Sm (15° — 60°)	= 0.100 (Kopp) (uncertain).

Manganese.

Sm (14° to 97°)	= 0.1217 (Regnault) (uncertain)

Iron.

Pinchon's determinations on the soft iron of "Berry" are the best.

Sm (0 to t) (for t up to 660°)	= 0.11012 + 0. 000025t + 0.00000005547t^2
Latent heat of change of state	= 5.3 Cal. absorbed between 660° and 720°.
Sm (0 to t) (for t = 720° to 1000°)	$= 0.218 - \frac{39}{t}$
Latent heat of change of state	= 6.0 Cal. absorbed between 1000° and 1050°.
Sm (0 to t) (for t = 1050° to 1160°)	$= 0.19887 - \frac{23.44}{t}$
Melting point	= 1600° (Roberts-Austen).
Latent heat of fusion	= 70 Cals. (calculated from 2.1 T rule
	= 69 Cal. (calculated from second rule).
Heat in solid iron at M. P.	= 300 Cal. (calculated).
Heat in liquid iron at M. P.	= 370 Cal. (calculated).
S (liquid) estimated	= 0.22.

Nickel.

Pionchon obtained the following results:

Sm (0 to t) (for t up to 230°)	= 0.10836 + 0.00002233t.
Latent heat of change of state	= 4.64 Cal. absorbed between 230° and 400°.
Sm (0 to t) (for t = 440° to 1050°)	$= 0.099 + 0.00003375t + \frac{6.55}{t}$
Melting point	= 1450°.
Latent heat of fusion	= 62 Cal. by 2.1 T rule.
	= 68 Cal. by second rule.

Cobalt.

Sm (0 to t) (for t up to 900°)	= 0.10584 + 0.00002287t + 0.0000000022t^2 (Pionchon)
Sm (0 to t) (for t over 900°)	$= 0.124 + 0.00004t - \frac{14.8}{t}$ "
Latent heat of fusion	= 68 Cal. (calculated).

Copper.

Sm (0 to t)	= 0.0939 + 0.00001778t (Frazier and Richards).
Melting point	= 1085°.
Heat in melted copper at M.P.	= 162 Cal. (Frazier and Richards)
Latent heat of fusion	= 43.3 Cal. (observed) Frazier and Richards).
	= 44.8 Cal. (calculated by 2.1 T rule).
	= 46.2 Cal. (calculated by second rule).
S (liquid) estimated	= 0.133 per kilogram.
	= 0.24 B. T. U. per pound.

Zinc.

Sm (0 to t)	= 0.0906 + 0.000044t.
Melting point	= 420°
Heat in solid metal at M. P.	= 45.2 Cal.
Heat in liquid metal at M. P.	= 67.8 Cal. (Person).
Latent heat of fusion	= 22.6 Cal. (observed).
Latent heat of fusion	= 22.4 Cal. (calculated by 2.1 T rule).
Latent heat of fusion	= 24.6 Cal. (calculated by second T rule).
S (liquid) (calculated)	= 0.1275 (from specific heat before fusion).
Boiling point	= 930°.
Latent heat of vaporization	= 23 T = 27,670 Cal. for Zn = 65.
	= 425 Cal. per kilogram.
	= 765 B. T. U. per pound.
S (vapor) per cubic meter	= 0.225 Cal. (assumed).
per cubic foot	= 0.014 pound Cal.
per cubic foot	= 0.025 B. T. U.
per kilogram	= 0.076 Cal.
per pound	= 0.136 B. T. U.

GALLIUM.

Sm (12° to 23°)	= 0.079 (Bettendorf).
Melting point	= 30°.
Latent heat of fusion	= 19.1 Cal. (Berthelot).
Sm (liquid) (30° to 119°)	= 0.0802 (Berthelot).

ARSENIC.

Sm amorphous (21° to 65°)	= 0.0758 (Bettendorf and Wulner)
crystallized (21° to 65°)	= 0.083 (Bettendorf and Wulner)
Sublimation temperature	= 450° to As^4.
Latent heat of sublimation	= 25 T = 18,075 Cal. for As^4 = 300 = 60 Cal. per kilo. (calculated).

SELENIUM.

Sm (60° to 250°)	= 0.084 (Bettendorf and Wulner)
Melting point	= 125°.
Latent heat of fusion	= 13 Cal. per kilogram (second rule).
Boiling point	= 690° (Berthelot).
Latent heat of vaporization	= 22,150 Cal. for Se^2 = 158 (calculated). = 140 Cal. per kilogram.

BROMINE.

Sm (solid) (— 10° to — 77°)	= 0.0843 (Regnault).
Melting point	= — 7°.
Latent heat of fusion	= 16.2 Cal. (Regnault).
Sm (liquid) (— 6° to + 58°)	= 0.105 + 0.0011t.
Boiling point	= 58°.
Latent heat of vaporization	= 43.75 Cal. (Berthelot and Gier)
S (vapor) per kilogram	= 0.0555 Cal.
per pound	= 0.0999 B. T. U.
per cubic meter	= 0.80 Cal.

STRONTIUM.

Sm (solid) (0° to 100°)	= 6.4 Cal. per Sr = 87 (assumed) = 0.0735 Cal. per kilogram.
Melting point	= bright red heat.

ZIRCONIUM.

Sm (0° to 100°)	= 0.0662 (Mixter and Dana).

COLUMBIUM.

Sm (0° to 100°)	= 6.4 Cal. per Cb. = 94 (assumed) = 0.068 Cal. per kilogram.
Melting point	unknown.

MOLYBDENUM.

Sm (5° to 15°)	= 0.0659 Cal. (De la Rive et Marcet).

PALLADIUM.

Sm (0 to t)	= 0.0582 + 0.00001t (Violle).
Melting point	= 1500°.
Heat in solid metal at M. P.	= 109.8 Cal. (Violle).
Heat in melted metal at M. P.	= 146.1 Cal. (Violle).
Latent heat of fusion	= 36.3 Cal. per kilo. (observed). = 36.1 Cal. by calculation, rule 2. = 65.3 B. T. U. per pound.

SILVER.

Sm (0 to t) (up to 400°)	= 0.0555 + 0.00000943t.
(over 400°)	= 0.05758 + 0.0000044t + 0.000000006t^2 (Pionchon).
Melting point	= 962°
Heat in solid metal at M. P.	= 64.8 Cal. (Pionchon).
Heat in melted metal at M. P.	= 89.15 Cal. (Pionchon).
Latent heat of fusion	= 24.35 Cal. (Pionchon). = 23.5 Cal. (calculated by rule 2)
S (liquid) (962° to 1020°)	= 0.0748 Cal. (Pionchon). = 0.0782 (calculated from solid state at M. P.).
Boiling point (approximtely)	= 1600° (V. Meyer).
Latent heat of vaporization	= 23 T = 43,080 Cal. for Ag = 108 = 397 Cal. per kilogram. = 715 B. T. U. per pound.
S (vapor) per cubic meter	= 0.225 Cal. (assuming it monatomic).
per cubic foot	= 0.014 pound Cal.
per cubic foot	= 0.025 B. T. U.
per kilogram	= 0.046 Cal.
per pound	= 0.082 B. T. U.

CADMIUM.

Sm (0 to t)	= 0.0546 + 0.0000121t (Naccari).
Melting point	= 321.7°
Heat in solid metal at M. P.	= 18.81 Cal. (Naccari).
Heat in melted metal at M. P.	= 31.83 Cal. (Person).
Latent heat of fusion	= 13.02 Cal. per kilogram.
S (liquid) (calculated)	= 0.0623 (from S of solid at M. P.)
Boiling point	= 778° (Berthelot).
Heat in liquid metal at B. P.	= 50.26 Cal. (calculated).
Latent heat of vaporization	= 23 T = 24.173 Cal. for Cd = 112 = 216 Cal. per kilogram. = 389 B. T. U. per pound.
S (vapor) per cubic meter	= 0.225 Cal. (assumed by rule).
per cubic foot	= 0.014 pound Cal.
per cubic foot	= 0.025 B. T. U.
per kilogram	= 0.0446 Cal.
per pound	= 0.0802 B. T. U.

TIN.

Sm (0 to t)	= 0.0560 + 0.000044t (Bede and Regnault).
Heat in solid metal at M. P.	= 14.34 Cal. (by above formula).
Heat in melted metal at M. P.	= 28.16 Cal. (Richards).
Latent heat of fusion	= 13.82 Cal. per kilogram. = 13.7 Cal. (by calculation, rule 2)
Sm (0 to t) (for t = 232° to 1000°)	$= 0.06129 - 0.000010474t + 0.000000010345t^2 + \frac{14.37}{t}$ (Pionchon)
S (liquid) (250° to 340°)	= 0.0637 (Person).
Boiling point approximate	= 1550° (Carnelly).
Heat in liquid metal at B. P.	= = 159 Cal. (Pionchon's formula)
Latent heat of vaporization	= 23 T = 31,930 Cal. for Sn = 118 = 271 Cal. per kilogram. = 487 B. T. U. per pound.
S (vapor) per cubic meter	= 0.225 Cal. (assuming it monatomic).
per cubic foot	= 0.014 pound Cal.
per cubic foot	= 0.025 B. T. U.
per kilogram	= 0.0424 Cal.
per pound	= 0.0764 B. T. U.

ANTIMONY.

Sm (0 to t)	= 0.04864 + 0.0000084t (Naccari)
Melting point	= 632°.
Heat in solid metal at M. P.	= 34.1 Cal. (by above formula).
Heat in melted metal at M. P.	= 74.3 Cal. (Richards).
Latent heat of fusion	= 40.2 Cal. per kilo. (Richards). = 15.8 Cal. (calculated by 2.1 T rule). = 16.0 Cal. (calculated by second rule).

There is a very large discrepancy here, which may be due to the value 74.3, determined by the writer, being too high, or Naccari's results being too low. Further experiments by the writer have confirmed Naccari's results, and leave the latent heat of fusion of antimony anomolous. It should be, by two rules, about 16, and it appears to be 40. Possibly the water oxidizes it as it is poured melted into the calorimeter.

S (liquid) (632° to 830°)	= 0.0605 (Richards).
Boiling point	= 1600° (Biltz and V. Meyer).
Heat in liquid metal at B. P.	= 131.4 Cal. (calculated).
Latent heat of vaporization	= 23 T = 43,080 Cal. for Sb = 120
	= 359 Cal. per kilogram.
	= 646 B. T. U. per pound.
S (vapor) per cubic meter	= 0.225 Cal. (assuming vapor monatomic).
per cubic foot	= 0.014 pound Cal.
per cubic foot	= 0.025 B. T. U.
per kilogram	= 0.0416 Cal.
per pound	= 0.0749 B. T. U.

TELLURIUM.

Sm (solid) (15° to 100°)	= 0.0525 Cal. (Fabre).
Melting point	= 455° (Richards).
Heat in solid metal at M. P.	= 27.3 Cal. (Richards).
Heat in melted metal at M. P.	= 46.3 Cal. (Richards).
Latent heat of fusion	= 19.0 Cal. (Richards).
	= 17.0 Cal. (calculat'n from rule 2)
	= 34.2 B. T. U. per pound.

IODINE.

Sm (solid) (9° to 98°)	= 0.05412 (Regnault).
Melting point	= 114°.
Latent heat of fusion (1 kilo.)	= 11.7 Cal. (Person).
Boiling point	= 183°.
Latent heat of vaporization	= 23.95 Cal. per kilogram (Fabre and Silberman).
S (vapor) 1 kilogram	= 0.03489 (constant pressure for I^2).
1 cubic meter	= 0.4088
S (vapor) (above 1200°)	= 0.225 per cubic meter for I.
	= 0.0394 per kilogram.
Latent heat of change $I^4 = 2I$	= 7,240 Cal. per formula, I^2.
	= 28.5 Cal. per kilogram of vapor.

BARIUM.

Sm (0° — 100°)	= 0.05 (Mendeleeff).

TANTALUM.

Sm (0° — 100°)	= 6.4 per Ta = 183 (rule).
	= 0.035 Cal. per kilogram.

TUNGSTEN.

Sm (0° to 15°)	= 0.035 Cal. per kilo. (De la Rive and Marcet).

IRIDIUM.

Sm (0 to t)	= 0.0317 + 0.000006t (Violle).
Melting point	= 1950° (Voille).
Latent heat of fusion	= 2.1 T = 4668 Cal. for Ir = 193.
	= 24.2 Cal. per kilogram.
	= 28.0 Cal. per kilogram by rule 2.
S (liquid)	= 0.055 (by rule, from solid at M. P.).

PLATINUM.

Sm (0 to t)	= 0.0317 + 0.000006t (Violle).
Melting point	= 1775° (Violle).
Heat in solid metal at M. P.	= 75.2 Cal. per kilogram (Violle)
Heat in melted metal at M. P.	= 102.4 Cal. per kilogram.
Latent heat of fusion	= 27.2 Cal. per kilogram.
	= 26.3 Cal. (calculated by rule 2)
S (liquid)	= 0.053 Cal. (by rule, from solid at M. P.)

GOLD.

S (from 0° to 600°)	= 0.0316 — constant (Violle).
Heat in metal at 600° (to 0°)	= 18.96 Cal.
Sm (0 to t) (from 600 to M. P.)	= 0.0289 + 0.0000045t + $\frac{\text{——}}{\text{(Violle)}\quad t}$
Heat in solid metal at M. P.	= 34.63 Cal. (by above formula).
Heat in melted metal at M. P.	= 50.93 Cal. (Roberts-Austen).
Latent heat of fusion	= 16.3 Cal. per kilogram.
	= 15.5 Cal. (calculated by rule 2)
	= 14.4 Cal. (calculated by rule 1)
S (liquid)	= 0.0358 (from S of solid at M.P.)

MERCURY.

S (solid) (at — 59°)	= 0.0319 (Regnault).
Sm (liquid) (— 36° to 0°)	= 0.0333 (Pettersson).
Sm (0 to t) (0 to 250°)	= 0.03337 — 0.00000275t + 0.000000667t^2 (Naccari).
Melting point	= — 40° C.
Latent heat of fusion	= 2.84 Cal. per kilo. at — 40° (Person).
Boiling point	= 356°.
Latent heat of vaporization	= 77.5 Cal. per kilogram (Fabre and Silberman).
	= 72.5 Cal. (calculation by Trouton's rule).
S (vapor) per cubic meter	= 0.225 Cal. constant pressure.
per cubic foot	= 0.014 pound Cal.
per cubic foot	= 0.025 B. T. U.
per kilogram	= 0.025 Cal.
per pound	= 0.045 B. T. U.

THALLIUM.

Sm (17° to 100°)	= 0.03355 (Regnault).
Melting point	= 290°.
Latent heat of fusion	= 2.1 T = 1182 Cal. for Tl = 204.
	= 5.8 Cal. per kilogram.
	= 5.8 Cal. per kilo. (by rule 2).
Boiling point	= 1700° (approximately) (Biltz and V. Meyer).
Latent heat of vaporization	= 45,380 Cal. by Trouton's rule, Tl = 204.
	= 224.5 Cal. per kilogram.
S (vapor) per cubic meter	= 0.225 Cal. (if monatomic).
per cubic foot	= 0.014 pound Cal.
per cubic foot	= 0.025 B. T. U.
per kilogram	= 0.024 Cal.
per pound	= 0.043 B. T. U.

LEAD.

Sm (0 to t)	= 0.02925 + 0.000019t (Bede and Regnault).
Melting point	= 326°
Heat in solid metal at M. P.	= 11.6 Cal. (from above formula)
	= 11.6 Cal. (observed, Le Verrier)
Heat in liquid metal at M. P.	= 15.6 Cal. (Person).
Latent heat of fusion	= 4.0 Cal.
S (liquid) (335° to 430°)	= 0.0402 Cal. (Person).
	= 0.0418 Cal. (calculated from solid metal at M. P.)

BISMUTH.

Sm (0 to t)	= 0.0285 + 0.00002t (Regnault and Bede).
Melting point	= 267°
Heat in solid metal at M. P.	= 9.0 Cal. (from above formula)
Heat in melted metal at M. P.	= 21.0 Cal (Person).
Latent heat of fusion	= 12.0 Cal. (Person).
Sm (liquid) (280° to 360°)	= 0.0363 (Person).

THORIUM.

Sm (0 to 100°)	= 0.0276 (Nilson).

URANIUM.

Sm (0 to 100°)	= 0.028 (Blümcke).

CORRESPONDENCE.

Electrolytic Copper.

To the Editor of Electrochemical and Metallurgical Industry:

Sir—I herewith send you a photograph of electrolytic copper which shows its crystalline structure very clearly.

The piece was broken from the lower corner of a full size cathode which had been operating under bad conditions in an

CRYSTALLINE STRUCTURE OF ELECTROLYTIC COPPER.

insoluble anode tank. There was presumably a very high current density at this corner.

The photograph magnifies about one and a half diameter.

LAWRENCE ADDICKS.

Perth Amboy, N. J.

Notes.

AMERICAN ELECTROCHEMICAL SOCIETY.—The next meeting of the American Electrochemical Society will be held on September 18, 19 and 20, at Bethlehem, Pa., in response to an invitation tendered by the president of Lehigh University. At the May meeting of the Board of Directors the following gentlemen were elected members: Hubert Buckley, Niagara Falls, N. Y.; H. F. Lewis, Boston, Mass.; Theo. W. Richards, Cambridge, Mass.; Edgar F. Smith, Philadelphia, Pa. At the June meeting the following gentlemen were elected members: Chas. Butters, Berkeley, Cal.; Clarence P. Hatter, Chicago, Ill.; Ralph D. Mershon, New York; Jas. K. Pumpelly, Indianapolis, Ind.; Harvey L. Williams, Bristol, Tenn.

SULPHATE OF AMMONIA FROM PEAT.—According to a recent statement in the *London Times*, the results obtained during the past two years at an experimental plant near London, in tests of the process of Eschweiler and Woltereck for utilizing peat for the production of sulphate of ammonia, have been so encouraging that $150,000 are now being spent on a complete recovery plant in the midst of the peat lands of Carnlough, Antrim County, Ireland. While the drawback to the use of peat as an industrial material has hitherto been the difficulty and expense of freeing it from its inherent moisture, it is claimed that the presence of up to 50 per cent of moisture is a positive advantage in the new process, and that there is a recovery of 68 per cent of ammonia in the form of the sulphate, which is a valuable fertilizing agent.

THE CANADIAN ENGINEER.—It is announced that after June 1 *The Canadian Engineer* will be issued and conducted under new auspices. For twelve years this journal has been published by Biggar-Samuel, Ltd., with business offices at Montreal and editorial headquarters in Toronto. It has now been bought by the Monetary Times Printing Co., Ltd. The new editor is Mr. Samuel Groves, an English engineer, who was in 1904 lecturer on mines, furnace and foundry to the Carnegie Technical Schools in Pittsburg. Special attention is to be paid by the journal in future to metallurgical developments in Canada, "in order to meet the demands of the new era of prosperity in iron and steel, which one can hear coming on every passing breeze."

INDIANA UNIVERSITY.—We have received the 1905 catalogue of Indiana University, Bloomington, Ind. It contains in the first part a list of the board of visitors, trustees, faculty and officers, and historical notes on the university. Then follow the university regulations and an announcement of the courses for 1905-6. Among them are courses in elementary metallurgy and assaying, quantitative analysis, electrochemistry, lectures and laboratory work, special lectures and laboratory work on the deposition of metals, advanced electrochemistry and electrometallurgy, chemical engineering (Prof. Brown); physical chemistry, lectures, laboratory work and research work (Prof. Shinn), and a seminary in physical chemistry and electrochemistry. The register of students for 1904-5 shows a total of 1538 students (86 resident graduates and 1452 undergraduates).

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

THE MEETING OF THE IRON AND STEEL INSTITUTE.

The members of the Iron and Steel Institute—who held their last session in New York in September, 1904—held their annual London meeting at the building of the Institution of Civil Engineers, on May 11 and 12 last. The lecture hall was packed, when, after such formal business as the reading of the reports of the council and the treasurer, Mr. Carnegie relinquished the presidential chair in favor of Mr. Hadfield. The retiring president, in his pleasing valedictory speech, compared his period of office to that of the position of a constitutional monarch. Here, some rather wondered that the author of "Triumphant Democracy" could compare himself to such a personage. There was not much time given for wondering, for the next sentence evoked applause by its reference to the force behind the throne—Mr. Bennett Brough, the secretary. The rest was a declamation of the true cosmopolitanism of science. He (Mr. Carnegie) had been the first president of the institution who was not a British subject. He had had an advantage over many Americans—he had been born in Scotland. In any case, with age, any sense of international distinctions passed into nothingness—he looked with equanimity on the prospect that succeeding presidents might be Americans (without the credential of Scotch parentage) or Germans, Frenchmen, Swedes or Belgians. His immediate successor was not absolutely free from foreign taint; even Mr. Hadfield was ruled from behind the scenes by foreign influences. Your correspondent failed for a moment to appreciate the ripple of laughter which followed, then he recollected that Mrs. Hadfield was born in the United States.

Mr. Hadfield then took the chair, his first official announcements being that of a further donation by his predecessor of £5000 to the Carnegie Research Fund, and the handing to Professor J. O. Arnold of the Bessemer Gold Medal. In making this presentation Mr. Hadfield recited Professor Arnold's

services to the metallurgical knowledge of the world. The recipient's acknowledgement was tinged in its opening sentences by the spirit of badinage which had ruled a few moments before. This was well atoned for, that is, if atonement were needed, by Professor Arnold's handsome tribute to his collaborators at Sheffield. The meeting then settled down to enjoy Mr. Hadfield's selection of extracts from his presidential address. Mr. Hadfield is one of those rare men whose versatility is bewildering, being a combination of the successful manufacturer with the keen scientist, whose contributions to the meetings of the Institute are known throughout the scientific world. To these properties, the possession of which is everywhere acknowledged, Mr. Hadfield showed in his address high literary ability and a certain amount of statistical skill.

The address should be read carefully at one's leisure. Mr. Hadfield read extracts, from the 82 pages of which it is composed, for the space of 50 minutes, the reading suffering by reason of a desire to read as much as possible. Each section is in reality a monograph on a particular feature of a many-sided industry, whose sections of research and interest are perhaps too numerous to mention. Tributes to early metallurgists, many of whose names and pictures are rescued from obscurity. Perhaps—Mr. Hadfield does not say so—some of the opinions of these forgotten worthies are only worthy of note as curiosities. One of them is quoted as stating that steel "after being well cleaned, then heated, and quenched three or four times in equal parts of extract of radishes and water which contained earth-worms, cuts like lead." Another matter touched upon was the growth of the technical press, the contents of which were not ephemeral as was the case of daily papers written only for the moment. Metallurgy was now a distinct science, and a quotation was made of Borchers' asseveration that "the metallurgist has not only the task of supplying a product of a stated chemical composition, but he has also to supply the mechanical and constructive engineer with the same material in most diverse forms, with the most varied degree of hardness, strength and other physical properties. It is not by any means chemical analysis alone which will show him the way of fulfilling his task, which, as regards meeting such requirements, far surpasses that of supplying a material of a stated chemical composition." But a bare recital of some of the subjects touched upon by Mr. Hadfield in his address had better be given than isolated extracts. These include: alloys of iron with other elements, heat treatment, metallography, low temperature experiments, steel castings, war material, testing. The closing note foretelling an era of prosperity was gladly received. The prophet of a coming good time is always a more popular personality than one uttering jeremiads of doleful misgiving. Mr. Hadfield is, however, an authority of such weight that the prophesying of good was due to no desire to say nice things. The new president of the Iron and Steel Institute can well afford to despise either the popularity of one course, or the notoriety of the other.

At the close of the address the new president was warmly congratulated by Sir Edward Carbutt and Sir William White, who respectively proposed and seconded the vote of thanks.

Discussion of Papers at the Iron and Steel Institute.

The first papers read were those by Mr. S. Surzycki, of Czenstochowa, Poland, on "The Continuous Steel Process in Fixed Furnaces," and "Recent Developments of the Bertrand-Thiel Process in the Manufacture of Steel," by J. H. Darby, of Brymbo, and Mr. G. Hatton, of Round Oak. These were discussed simultaneously, a lengthy discussion being opened by Mr. Talbot, who criticized the authors of the second paper for giving details only from the Hoesch works in Germany, and then said that a basic lined tipping regenerative furnace which was used to refine molten pig-iron and take out more than 50 per cent of its impurities when working continuously with basic additions was not part of the Bertrand-Thiel process either, but was the continuous method of refining with which his name was connected. He (the speaker) considered it both from a practical and theoretical standpoint more advantageous to finish the steel in the one vessel rather than transfer it to another at practically the same temperature. As regards the composition of the slag, the figures given in two cases were only partial, and only 19 per cent of lime was shown. It was obviously necessary to know what the other bases were, especially the magnesia. In estimating the value of the slag the average weight per ton of steel obtained was also of importance. It was noticed that when the greater part of the refining was done in the continuous furnace, the bulk of the phosphorous was eliminated, but it still left .90 to be removed in the second furnace. As that was mixed with 25 per cent of scrap it would be interesting to know the percentage of phosphoric acid in the slag, and its weight per ton of steel.

Mr. Springorum, speaking as the manager of one of the first German works to adopt the process, replied at once to Mr. Talbot's criticisms. The slag contained about .8 per cent of phosphorus, .3 to .5 per cent of silicon, and about 1.5 per cent of manganese. The life of the furnace, without repair, was about 240 charges, and the phosphorus was from .8 per cent to .25 per cent, or .28 per cent. They started the process about a year ago, and he might say that they were now satisfied with it in every respect. It cost much less than the usual process, and the quality of the steel was as good; it was the best he knew. There was no difficulty in getting regularly .15 of phosphorus for soft steel, and .20 to .25 for a hard steel. The production was about 8 to 9 charges, and he was sure that they could have 10 charges without any difficulty.

Mr. F. W. Paul complimented Mr. Surzycki on the paper on the continuous process, but did not think that it was necessarily restricted to furnaces of 25 tons and over. Why could it not be applied to 10-ton furnaces? As regards Messrs. Darby and Hatton's paper, he asked for more information as to the composition of the slags and the necessity for using two furnaces. Comparing the sizes of the different Talbot furnaces in this country and America with those of Messrs. Darby and Hatton and Mr. Surzycki, as the latter produced 500 tons of ingots per week for 208 square feet of surface, the combined gas-heated mixture and two secondary furnaces should, on the same basis, produce 2016 instead of 840 tons per week.

Several other speakers followed, and the authors of the second paper replied to the discussion, stating that the German figures were quoted, as it was at the Hoesch works, that the best results were obtained. The transfer process was essential in the production of steel as low as 0.03 in sulphur, and 0.1 to 0.2 phosphorus, which could not be made without the secondary furnace. The high quality slag in the primary furnace was another advantage, saving the bulk of the phosphorus, the amount produced in the secondary furnace was negligible. The comparison of output with area of furnaces overlooked the circumstances that in America the metal contained 0.4 phosphorus, while at Round Oak and Brymbo pig-iron with 2 to 3 per cent phosphorus was used. The president then allowed Mr. Talbot to make a rejoinder to the effect that at Frodingham they worked with 2¼ per cent of phosphorus acid. There was no difficulty in working; it was merely a question of keeping the slag right, the process being continuous both in regard to metal and slag. The tilting furnace allows the slag to be taken off in any quantity, and whenever it is desired to do so.

The work of the second day began with Mr. Hadfield's temporary relinquishment of the chair to Mr. Windsor Richards, in order that the president might read an abstract of his paper on "Experiments Relating to the Effect on Mechanical and Other Properties of Iron and its Alloys Produced by Liquid Air Temperature." The discussion was opened by Mr. J. E.

Stead, who said that it was only natural to expect a metal to be more brittle at low temperatures, and that the chief interest in Mr. Hadfield's work lay in his discovery that alloys of iron with nickel manganese and carbon were quite ductile at such low temperature as that of liquid air. Professor Barrett laid emphasis upon the close alliance of certain different physical properties. In taking the electrical conductivity of the alloys, one could almost determine the percentage of carbon present. That was an exceedingly quick and easy thing to do, and if one had the electrical conductivity one practically had the thermal conductivity. Where there was a drop in the electrical conductivity there was a corresponding drop in the thermal conductivity. The 1414 B. iron manganese nickel alloy was one of the most remarkable that had ever been given to the world. Not only did it show the extraordinary change in properties when cooled to a low temperature, but its properties from an electrical and magnetic point of view were equally wonderful. It had the highest electrical resistance and the highest thermal resistance of any alloy that he had examined. Another remarkable feature was its extraordinary thermo-electrical property. Connecting the alloy with another piece of iron, and warming the ends, making a thermoelectrical junction of it, when its temperature was raised to about 400° C., or 500° C., the e.m.f. increased until suddenly it reached the maximum, and then, although one might go on raising the temperature from a black heat up to an intense white heat, there was absolutely no change in the e.m.f., which was constant through an enormous range of temperature. That suggested an exceedingly simple method of obtaining a constant e.m.f., which physicists very much wanted.

Mr. Gledhill, who spoke later on, brought the discussion from its physical and laudatory phases into a more commercial atmosphere, by pointing out that if anything could be done to carry out in a practical form the liquid air treatment of large masses of steel, great value would result. Of the remaining speeches little need be said.

Mr. Gayley's supplementary paper on "Dry Air Blast" evoked a spirited discussion. The general concensus of opinion was well expressed by Mr. Harbord, who said that, while a considerable amount of heat would be carried away in the gases when using moist air, the real saving was due to the regularity of work in the furnace. One remark, and that a closing one by Mr. Windsor Richards, foretelling a trial in the United Kingdom of the dry air blast, aroused much speculation as to when a paper on English experiences would be ready.

Only one speech was made on Mr. Axel Sahlin's paper on cleaning blast furnace gas, the speaker taking the attitude that so far as gas engines were concerned there was no need to demonstrate at this late period the necessity of cleansing gases.

MARKET QUOTATIONS.

Almost without exception the nominal prices of last month are still current. Copper sulphate has receded to £21 per ton, but the various soda compounds are unchanged. Shellac is again cheaper, being quoted at 145s. to 155s. per cwt. As for Para rubber, the demand is so great that fancy prices varying between 6s. and 7s. per pound are being paid, the wide range being due to the differences of quality coming from the various sources of supply. A rubber boom is now in progress in Ceylon, and extensive plantations are being laid out. The incentives to the chemist to produce a substitute synthetically are greater than ever. The incubus of past failures is in this case a heavy one.

Cleveland pig-iron continued to rise in price until 55s. per ton was reached on May 17. Speculation being the cause of the rise; an abrupt fall to 46s. 6d. took place on the 18th, and the closing price on May 31 was 45s. 6d. Copper has varied slightly from day to day, the tendency being generally downward, until the 24th, when a bottom price of £63 5s. was reached. Prices have since hardened to £65. Tin, which fetched £138 10s. on May 1, fell to £135 5s. by the middle of the month, closing at £136 5s. Lead has improved slightly, closing at £13 5s. per ton for ingot lead (English), and £14 5s. for sheet lead. Zinc is 10s. cheaper at £26 7s. 6d. per ton, while quicksilver is fetching from 145s. to 147s. 6d. per 75-pound flask.

London, June 3.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

By GEORGE P. SCHOLL, PH. D.

ELECTRIC FURNACES AND FURNACE PRODUCTS.

Method of Heating Carbon Articles.—F. J. Tone, Niagara Falls. Patent 786,859, April 11, 1905. Application filed April 2, 1904.

The method provides for the treatment of carbon articles, such as carbon brushes, battery plates and furnace electrodes by heating them in an electric furnace. The latter is provided with a resistance conductor, which, however, is not in contact with the materials to be heated, so that the current is practically confined to the conductor. It is claimed that this arrangement allows the carbon articles to be heated by convection and radiation, and results in a more uniform distribution of the heat. As shown in Fig. 1, the furnace consists of a resistance conductor 1, built up of plates or blocks of carbon. It rests upon a refractory base 3, and the articles to be heated are separated from it by a space 5, good results having been obtained with a space of ½ to ¾ in. between the core and the articles. The articles may be covered on the outside by a thin layer of powdered carbon 6 and a suitable refractory material. The sides and ends of the furnace are built up of brick walls 8. An alternative form of furnace, shown in the patent, contains several conductors, arranged parallel to each other, the groups of articles to be heated being interposed between them. This form of furnace is stated to be particularly useful for treating carbons of large size or considerable length, and may be operated in a continuous manner by connecting the cores successively with the source of current.

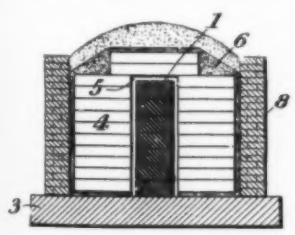


FIG. 1.—TONE FURNACE.

Arc Electrode.—D. A. Holmes, S. A. Tucker and E. van Wagenen, New York. Patent 789,609, May 9, 1905. Application filed Aug. 6, 1904.

The invention relates to an electrode to be used for arc lighting, which is formed of zirconium carbide, mixed with any desired percentage of a binding material, such as lampblack, coal tar, molasses, etc. The zirconium carbide is stated to be usually manufactured in an electric furnace, and is prepared from the mineral zircon mixed with an excess of carbon. As it is made at a very high temperature, the silicon from the zircon is distilled off, and the carbide is formed by the

combination of the zirconium and the carbon. The compound thus formed is stated to be of great stability, and various advantages are claimed for the electrodes, of which it forms the essential part.

Electric Furnace.—T. S. Prenner, Scranton, Pa. Patent 790,226, May 16, 1905. Application filed March 21, 1903.

The furnace consists essentially of a heating chamber, closed at the top, into which two electrodes enter through passages in the side walls, being arranged at angles of 120° from each other. A third electrode is arranged below these two, preferably in a vertical position. The electrodes are maintained at a proper distance from each other by electrical means, which are described in detail in the lengthy specification. In the same manner the action of the feeding mechanism is controlled, so that, if the arcs have not reached their normal condition, the feed of material will be slackened. If the arcs are broken, or there is no, or an excessive, current passing, the feed of the material will cease altogether.

Process of Reducing Metallic Compounds.—E. F. Price, Niagara Falls. Patent 790,389, May 23, 1905. Application filed Aug. 31, 1904.

The essential point in this process consists in heating a charge of a refractory metallic compound, such as silica and alumina, mixed with a reducing agent, to the reduction temperature for a relatively short period, while the maximum temperature is kept below the volatilization point of the reduced metals, and the metal is at once withdrawn from the region of maximum temperature. The process may be carried out either in the incandescent or in the arc furnace, constructions for both types being shown in the specification. The incandescent furnace (Fig. 2) consists essentially of a vertical stack 1 of firebrick or masonry, provided with a refractory nonconducting lining 2 of magnesite or siloxicon and a water jacket 3. The electrodes 5 are introduced through the water-cooled top 4, and constitute one terminal of the current. The other terminal is formed by the carbon hearth 8, resting upon the metal plate 9, and connected to the course of current by connection 10. Tap hole 13 is intended for slag and tap hole 14 for metal. A gas outlet 15 is also provided. A charge 16, *f. i.*, silica and carbon, is fed into the furnace until it rises to and surrounds the lower ends of the depending electrodes 5. Current is then passed between these electrodes and the carbon hearth, and the charge, as soon as it is sufficiently heated, begins to act as a resistance conductor. As the cross-section of the furnace gradually decreases from the top of the furnace to the neck 11, the charge is gradually heated up higher until it reaches the necessary reduction temperature. The reduced metal then melts and at once drops out of the zone of maximum temperature into the cooler receptacle 12; it may be allowed to accumulate there in a layer 17, and withdrawn from time to time through the tap hole, while the layer of slag 18 accumulating on top of the metal is withdrawn as desired. Molten metal, or pieces of metal, either of that to be reduced or of an alloying metal, may be introduced into the furnace with the charge and allowed to percolate down through it for the purpose of collecting any scattered particles of reduced metal and carrying them into the body 17. The process and the several furnaces shown are stated to be suitable for reduction of refractory compounds or mixtures containing two or more metals, for example, manganiferous iron ores for the production of ferro-manganese.

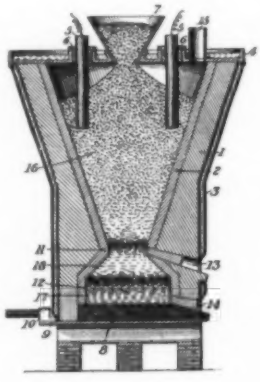


FIG. 2.—PRICE FURNACE.

Process of Reducing Metallic Compounds. E. F. Price, Niagara Falls. Patent 790,390, May 23, 1905. Application filed Aug. 31, 1904.

The process is based on the same principle as the preceding one, namely, to heat the charge for a relatively short period to its reduction temperature and allowing the metal to be immediately withdrawn from the region of the maximum. The furnaces which are stated to be used are, however, not incandescent, but arc furnaces; they are provided with a carbon lining, serving as one electrode, and have a central electrode, which depends vertically into the furnace to a point quite close to the bottom. The arc is sprung at this point, the rest of the furnace being filled with the charge. The reduced metal falls directly into a separate vessel, or an annular metal receptacle in the bottom of the furnace, whence it is tapped off.

Process of Smelting Metallic Compounds.—E. F. Price, Niagara Falls. Patent 790,391, May 23, 1905. Application filed Aug. 31, 1904.

The process relates to the production of ferrochromium from chromite, in order to produce metal low in carbon. The furnace shown in the specification consists of a body of firebrick masonry, with refractory lining of magnesite, siloxicon or carbon. Electrodes of opposite polarity depend into it. An arc is established between the electrodes or the electrodes and the carbon lining, when the latter is used, and a small amount of the charge, *f. i.*, a mixture of chromite, coke, lime and silica, is fed into the bottom of the furnace. It is then gradually filled, until in its normal working condition the electrodes are deeply embedded in the charge. This deep body of the charge, surrounding the electrodes, is claimed to effectively retain the heat within the furnace, both increasing the production of metal and maintaining the slag in a molten condition without special attention. It is stated that the use of this deep body is made possible by, and necessitates the use of, a minimum electromotive force, since the voltage usually employed in furnaces of this character would cause excessive waste of current by shunting or short circuiting through the charge if no current regulator were employed, which is a commercially impracticable method of procedure. Heat losses and oxidation of the hot exposed surfaces of the electrodes are also claimed to be avoided. The furnace is operated continuously, the metal and slag being drawn off and fresh materials added as required. The process is stated to be also applicable to the production of ferrosilicon from a mixture of silica and carbon.

Process of Smelting Iron Ores and Producing Ferrochromium.—E. F. Price, Niagara Falls. Patent 790,393, May 30, 1905. Application filed Oct. 19, 1904.

The reduction of chromite, magnetite and other ores of iron, as described in this specification, is carried out in an incandescent furnace, the charge and its products being employed as a resistance conductor. The furnace is of inverted cone-shaped form, decreasing in diameter from the top to the bottom. A water-cooled iron plate on the bottom contributes one electrode, while a water-cooled ring around the top serves as the other one. A body of refractory material, surrounded by a water jacket, operates the two. A body of the iron or alloy produced by the reaction in the charge is allowed to accumulate on the iron-plate bottom, and is liquid except at its lower portion, which is kept in a pasty or solid condition, owing to the action of the cooling water which circulates through the plate. Thus, during the process the bottom plate constitutes merely a terminal of the current, while the accumulated body of metal really serves as the lower electrode. By employing a charge containing a predetermined amount of carbon, it is claimed to be possible to produce an alloy with a minimum percentage of this element.

Process of Smelting Refractory Ores.—E. F. Price, Niagara Falls. Patent 790,394, May 23, 1905. Application filed Nov. 7, 1904.

The process consists in smelting an electrically conductive charge of a refractory ore and a reducing agent in a down-

wardly converging furnace between water-cooled metal electrodes. The latter distinguish it from the Cowles furnace, which is of a similar type, but in which the electrodes are of carbon. This construction was adopted on account of the expense and the difficulty of obtaining large blocks of carbon and of their rapid wearing, due to the attrition of the charge. One electrode is a water-cooled metal plate in the bottom of the furnace, while the other is constituted by a water-cooled metal ring around the top. It is stated that the process is applicable to the reduction of various refractory ores, such as those of chromium, titanium, vanadium, aluminium, calcium, boron, etc.

Process of Producing Low-Carbon Metals or Alloys.—E. F. Price, Niagara Falls. Patent 790,395, May 23, 1905. Application filed Nov. 22, 1904.

The distinguishing feature of this process is the fact that the production of low-carbon ferrochromium and other metals and alloys is effected by a non-continuous process in two steps. In the first stage an alloy with a relatively high percentage of carbon is produced by smelting a charge containing sufficient carbon to protect the carbon electrodes. The alloy thus produced is tapped from the melting furnace, and allowed to solidify. The ingot is then broken into fragments, which are mixed with a decarburizing agent, such as lime, and the mixture is smelted preferably in a furnace in which the charge serves as a resistance conductor, the carbon reacting on the lime to produce calcium carbide, which is separated from the purified alloy, the two collecting in the bottom of the furnace in superimposed layers.

Process of Producing Low-Carbon Metals or Alloys.—E. F. Price, Niagara Falls. Patent 790,396, May 23, 1905. Application filed Nov. 22, 1904.

The present process, claimed to be applicable to the production of low-carbon ferrochromium and other metals and alloys, differs from the preceding one by being conducted in a continuous operation in two stages. In the first stage an alloy with a relatively high percentage of carbon is produced, which process is carried out in the same manner and in a furnace of the same construction as in the preceding patent. Instead of cooling and breaking up the ingots, before treating it in the second furnace, the metal produced in the first one is run into a second furnace, or into another compartment in the same furnace, and is subjected to the action of a decarburizing agent. As such lime is used, a layer of molten lime being preferably maintained on the surface of the molten alloy, until the desired percentage of carbon has been withdrawn. The carbon reacts on the lime to produce calcium carbide, which separates as above from the alloy.

Process of Producing Low-Carbon Metals or Alloys.—E. F. Price, Niagara Falls. Patent 790,397, May 23, 1905. Application filed Dec. 10, 1904.

This process presents still another modification of the methods used in the two preceding ones. The high carbon alloy, *f. i.*, ferrochromium, if a mixture of chromite, coke, lime and silica is used, is produced by heating this charge in a furnace, the carbon lining of which constitutes one electrode, while a carbon rod depending vertically into the furnace constitutes the other one. The furnace is an arc furnace. The high carbon alloy thus produced is percolated through a vertical chamber, which is filled with a granular body of a decarburizing agent, *f. i.*, broken lime. The latter forms calcium carbide as above, withdrawing the required amount of carbon. An electric current is passed through this vertical chamber by means of electrodes suitably arranged at the top and the bottom, in order to maintain the granular body of lime at a high temperature.

Process of Producing Ferrochromium.—E. F. Price, Niagara Falls. Patent 790,392, May 23, 1905. Application filed Aug. 31, 1904.

The furnace employed for carrying out this process tapers again in cross-section from the top to the bottom. The electrodes which depend from the top are carbon rods, while a carbon plate constitutes the hearth of the furnace, and at the same time serves as the other electrode. The reduced iron and chromium form a molten alloy which drops below the charge sustained by the converging walls into the crucible, which is constituted by the lower end of the furnace. A layer of molten slag is preferably maintained on the molten alloy beneath the charge.

ELECTROLYTIC PRODUCTION OF METALS AND ALLOYS.

Utilizing Spent Pickle Liquors.—A. S. Ramage, Detroit, Mich. Patent 788,064, April 25, 1905. Application filed Jan. 31, 1905.

The process is claimed to be applicable to the utilization of ferrous sulphate liquors from the pickling of iron or copper, etc. In carrying out the process the pickle liquor containing ferrous sulphate and free sulphuric acid, the latter in too small amounts for efficient pickling, is saturated with sulphurous acid. This operation is performed in a tower filled with coke, over which the liquor is distributed and flows down. A current of sulphurous gas is introduced at the bottom of the tower, and, ascending, meets the stream of liquor. The acid liquor is then allowed to run into covered electrolytic vats, preferably so constructed as to force the liquor to flow in a tortuous fashion past the anodes and cathodes. The vats are lined and in electrical connection with the anodes, while the cathodes extend transversely across the vat. The vats are arranged on an inclined supporting structure. The pickle thus regenerated is drawn into a collecting tank and used over again.

Apparatus for Agitating the Contents of Electrolytic Cells.—E. A. Ashcroft, Weston, via Runcorn, England. Patent 788,506, May 2, 1905. Application filed Nov. 16, 1903.

The invention relates especially to electrolytic cells in which a fused electrolyte is employed at a comparatively high-current density, and requires agitation or circulation for moving and circulating an intermediate electrode of liquid metal, such as fused lead, in the production of caustic soda or metallic sodium. The inventor states that if a circular vessel containing fused chloride of sodium be carrying a current which enters the bath more or less centrally, and leaves its more or less

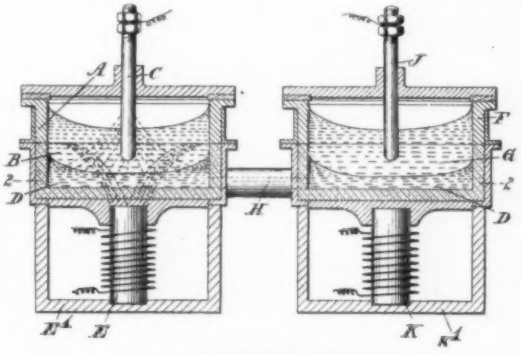


FIG. 3.—ASHCROFT'S APPARATUS.

peripherally, as when a fused lead cathode and a carbon anode are employed in the production of a sodium lead alloy or sodium amalgam from chloride of sodium, a common pot-electromagnet, having concentric poles, when placed concentrically beneath the bath, will set up a violent swirl of the whole contents of the bath. The necessary condition is, that the lines of magnetic force shall cut the lines of current—flow more or less at right angles to the direction of the required motion. The direction of rotation of the fluid armature will be according to the relative directions of the magnetism and the current flow. The apparatus, as shown in cross-section in

Fig. 3, consists of an electrolytic vessel A, containing an electrolyte B, such as sodium chloride. It has a central anode C of carbon, and a cathode D, which may be a mass of fused lead at the bottom of the cell. An electromagnet E with an iron pot E' is placed concentrically beneath the cell A. A second electrolytic vessel F, containing an electrolyte G of fused caustic soda, is connected with the first vessel by tangential passages H at the bottom of the vessels. The second cell is provided with a cathode J of nickel, and the anode consists of the intermediate electrode D, such as sodium-lead alloy, and the current entering the first cell at C is thus conducted through the alloy D to the second cell, where it leaves by the cathode J. An electromagnet K in an iron pot K' is placed concentrically beneath the vessel, as with the first one. If the swirls in the two vessels A and F be caused to take place in the same direction, a flow of the intermediate electrode will take place along the channels H.

Electrolytic Apparatus.—W. McA. Johnson, Iola, Kan. Patent 789,740, May 16, 1905. Application filed Aug. 14, 1903.

The apparatus is stated to be more especially intended for the separation of copper from sulphate solutions obtained by leaching soluble surface ores or roasted sulphide ores. The apparatus comprises a tank, lined with a material unaffected by the electrolyte and furnished with stationary cathodes, which consist preferably of the metal to be deposited, in the above instance of copper. Anodes, consisting of cast discs of hard lead, are mounted upon a rotatable shaft supported upon the tank. Each anode consists of a disc of hard lead, which carries a series of lead vanes. The purpose of the latter consists in directing a stream of the electrolyte against the faces of the adjoining cathodes, during electrolysis, in order to facilitate the deposition of the copper in commercially available form from weak or highly acid solutions.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

Industrial Applications.

Electrolytic Refining of Lead.—Hans Senn, in a dissertation presented to the University of Basle, and published in the *Zeit. f. Electrochemie*, April 14, gives results of his experiments on Betts' electrolytic lead refining process; he tested in addition the electrolytic refining of cadmium with the fluosilicate solution. The author experimented on the addition of various amounts of gelatine to lead nitrate and acetate solutions, without getting the coherent dense lead deposit obtained with the fluosilicate solutions, and says that in consequence the fluosilicic acid has some specific property not possessed by the nitrate and acetate solutions, and that the solid deposit is not the result of the action of the gelatine alone. In electrolytically refining cadmium the author used a solution containing about 20 per cent SiF_6 and 1.23 per cent of cadmium, which increased by solution of hydrogen on the electrodes during the experiment to 2.59 per cent cadmium. He found 0.3 gram of gelatine per liter to be a sufficient amount for the production of a solid, smooth deposit. The deposits were about 1 mm thick, and of very good quality. He found 0.1 gram gelatine per liter with the lead solution to be enough to produce a solid deposit. The author electrolytically refined a series of alloys of lead with copper up to 17, with bismuth up to 26.67 per cent, and with antimony up to 10 per cent. If a current density of not more than 1 amp. per square decimeter was used, in no case did the cathode deposits of lead show a detectable quantity of the impurity present in the anode.

He found in his experiments a slow decomposition of the electrolyte with separation of silica. In one experiment he electrolyzed a solution of fluosilicic acid with platinum electrodes, and obtained a gelatinous precipitate of silica. As the experiments were carried out in glass, the silica may have come from the glass. In one series of experiments the proportion of free acid in the electrolyte diminished from 11 to 8.56 per cent, and in another increased slightly, while the lead percentage went down from 9 per cent to 4.83 per cent and 2.48 per cent respectively, indicating absorption of solution of neutral salt by the anode slime.

The author investigated the electrolytic refining of lead-platinum alloys, in the hope of finding a cheaper separation of the lead from lead-platinum alloys obtained in refining platinum. The experiments were only partly successful, for the anode slime contained lead and platinum in about the proportion required by the formula $PtPb_2$. By greatly increasing the voltage only a little more lead may be removed from this compound. The author found in his experiments that the loss of lead at the anode was over 100 per cent of that required by theory from the current passed, while the deposit on the cathodes averaged 98 per cent. With deeper electrodes and solution, so that the action of the atmospheric oxygen would have been less in proportion, the cathode-deposited lead would probably be much nearer the theoretical. A summary of the results is given in the table below.

Electrometallurgy of Iron and Steel.—*Stahl und Eisen* of

Anode	Current Density Amp. per Sq. Dm.	Amperes.	Hours Run	Cathode Lead, Grams.	Slime, Grams.	In 25 Grams. Cathode Lead.	Composition Anode Slime		
							Pb		SnO_2
Lead + .92 per cent. Cu	0.59	.5	29	55.9	1.64	no Cu	....	23.41 Cu	....
Lead + .92 per cent. Cu	1.07	.9	24	83.3	0.87	no Cu	....	36.31 Cu	24.87
Lead + 1.006 per cent. Cu	1.55	1.3	18	90.2	3.11	no Cu	....	19.47 Cu	....
Lead + 1.006 per cent. Cu	2.30	2.	9	69.4	1.10	no Cu	10.03	57.96 Cu	25.12
Lead + 12 per cent. Bi	.59	.5	24	48.3	....	no Bi	....	70.49 Bi	....
Lead + 12 per cent. Bi	1.07	.9	7.25	25.	12.72	no Bi	....	42.76 Bi	....
Lead + 12 per cent Bi.	1.55	1.3	11	55.1	12.60	no Bi	....	35.44 Bi	....
Lead + 26.67 per cent. Bi	1.07	.9	17	59.	13.25	no Bi	12.4	83.97 Bi	1.82
Lead + 26.67 per cent. Bi	1.55	1.3	16.5	82.6	36.38	.94 per cent. Bi	34.83	60.15 Bi	1.26
Lead + 10.03 per cent. Sb	0.59	.5	30	57.9	8.58	no Sb	(9 p.c.F.)	67.71 Sb	....
Lead + 10.03 per cent. Sb	1.07	.9	8.5	29.5	5.19	no Sb	....	47.52 Sb	1.04
Lead + 10.03 per cent. Sb	1.55	1.3	22	110.3	18.52	.13 per cent. Sb	....	53.47 Sb	....
Lead + 9.81 per cent. Sb	1.55	1.3	18	90.3	10.43	.05 per cent. Sb	....	45.00 Sb	....

June 1 contains an address by Prof. W. Borchers on the present situation of the electrometallurgy of iron and steel. The author gave a review of the more important electric furnace processes which have been devised or introduced into practice. This review does not seem to contain anything new to our readers. However, the concluding words of the address are interesting. Prof. Borchers thinks that what has really been accomplished so far was the work of experimenters who were able electrical engineers, electrochemists and furnace designers, but were more or less unacquainted with the iron and steel industries, at least when they began their experiments. It is thus still too early to state definitely what may be accomplished by the electric furnace in the iron and steel industries. But the time is now ripe for experienced iron and steel men to take up the problem vigorously.

Magnetic Separation.—Iron Age, of June 22, contains an illustrated article on the Buchanan magnetic separator.

THEORETICAL AND EXPERIMENTAL.

Electric Laboratory Furnace.—A new type of electric laboratory furnace was described by J. A. Harker, in a paper read before the Royal Society on April 13, an abstract appearing in the London *Electrician* of May 19. The same furnace was also exhibited before the (British) Physical Society; an abstract of the latter paper may be found in the London *Electrician* of June 2. The furnace is designed for the attainment, in absence of noxious gases, of temperatures between 800° C. and 2200° C. The conductor conveying the electric current is a tube of solid electrolytes similar in composition to the filament of a Nernst lamp. An essential feature is that for many purposes the usefulness and life of a furnace constructed in this way may be much increased by adopting a "cascade" system of heating; that is, the energy supplied may be divided, so that only sufficient is put through the tubular conductor to raise its temperature, say, 1000° C. above its surrounding, the surrounding itself being maintained at 1000° C., thus enabling a temperature of 2000° C. to be attained in the tube without straining it unduly. The regulation of temperature in small furnaces of this type is so perfectly under control that very well-defined melting points may be taken with very small quantities of substance. The thermoelectric method has been used in these furnaces for determining the melting point of platinum, the mean result of the experiments giving 1710° C. within 5°. The furnace is shown in Fig. 1. The arrangement consists of an inner tube AB, formed of Nernst filament earths and heated by a current at 200 to 500 volts, supplied by flexible platinum terminals. This tube is surrounded by a jacket of pure zirconia, and that again by a fire-clay tube, kept at 1000° by means of a nickel coil CD. This ensures a uniform gradient of temperature.

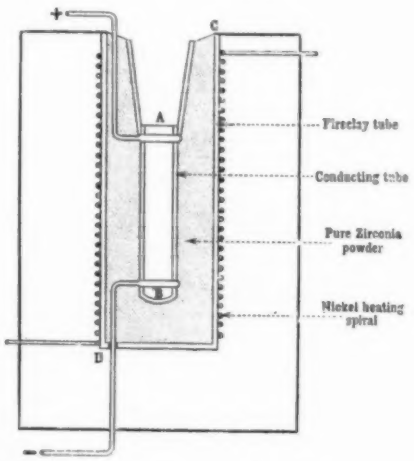


FIG. 1.—ELECTRIC FURNACE.

Chemistry of Electroplating.—In our Vol. II., page 389, we published in full W. D. Bancroft's paper read before the International Electrical Congress in St. Louis, and developing a tentative chemical theory of electroplating. This paper has now been enlarged and is published, together with some experimental work in support of his theory, in the April issue of the *Journal of Physical Chemistry*. The author has not changed his theory in any essential point. Some minor changes are as follows. One of his former general conclusions read: A fine-grained deposit is favored by high-current density and potential difference, by acidity and alkalinity, by low temperature and by presence of colloid. In his new statement he leaves out "by acidity and alkalinity." Another general conclusion of his former paper was that "solutions containing oxidizing agents appear to yield small crystals, while larger crystals are obtained from solutions containing reducing agents;" this statement is omitted under the general conclusions of the new paper. The following two general results are new: "Treeing is favored by anything which increases the fall of potential per unit length of electrolyte, or which increases the coarseness of crystallization; surface tension phenomena may also be a factor, though this has not been proved. The theory presented has been able to account for the phenomena, due to composition and concentration of the electrolyte to current density, temperature, solvent, colloids, other metals and cathodes. It has not accounted for the effect of acids and alkalies, nor for the effect of oxidizing and reducing agents; but this seems to be due to our ignorance of the chemistry of these solutions rather than to a defect in the theory."

Polarization of Metallic Anode.—In a paper published in the May issue of *Phil. Mag.*, S. R. Milner applies Nernst's theory of concentration cells to the calculation of the polarization of a metallic anode by a given constant or variable current. The anode chosen was in some of the experiments silver in a solution of nitric acid containing only a small amount of silver nitrate. The cathode was arranged in such a way that it was not polarized during the passage of the current. The author develops the theory for a certain construction of the cell on the basis of Nernst's and Planck's formulas. The results of his measurements agree with the theory even better than should be expected.

Electrolytic Chromium.—Chromium begins to become of considerable importance in the steel industries, especially in the manufacture of shells and tempered products, tool steels and the like, in general whenever properties of particular hardness are desired. It is introduced into the steel either in form of pure metallic chromium, as made by Goldschmidt's aluminothermic process, or in form of ferro-alloys, which are now made in considerable quantities, especially in the electric furnace. The question whether pure chromium could be produced commercially by electrolysis is still open. An advantage of such chromium would be that it is obtained in a very pure condition, but various authors have obtained such very different results that the whole subject is somewhat enveloped in mystery. H. R. Carveth and W. R. Mott publish in the March issue of the *Jour. of Phys. Chemistry* an interesting paper, in which they endeavor to determine the various factors which are of importance for the electrolytic production of chromium. In the present paper they only consider those cases where chromium acts as the base in trivalent compounds. The main results of their investigation are as follows: The presence of chromous salt appears to be essential to the successful deposition of the metal from its chloride or sulphate solutions. This has been proved by showing (*a*) that the current does work in reducing the chromous to the chromic salts; (*b*) that it is necessary to electrolyze the chromic salts for some time before the metal can be deposited with any considerable efficiency; and (*c*) that the efficiency is destroyed by

oxidation of the chromous salt. The temperature has a very decided influence upon the efficiency of deposition; this result is in direct opposition to those recorded by Neumann. For each special set of conditions there seems to be a temperature at which the loss in efficiency caused by the decomposition of the chromous salt is balanced by increased efficiency caused by other factors. For example, it was found that after the sulphate had been electrolyzed for some time, rise of temperature increased the efficiency; the same result was observed when the current density was lowered. For a chloride solution between 0° and 16° the same effects were noticed. As might be predicted, the more concentrated the solution the higher the temperature which may be advantageously employed. The nature of the anode solution affects the yield very considerably; that this is probably due to the diffusion of the anolyte into the cathode chamber is indicated by the peculiar results obtained in the continued efficiency runs. On continued electrolysis of the solutions of chromic salts, the efficiency rises from zero to a value which is practically constant. This may be accounted for by assuming that the absolute and relative masses of the chromous and chromic salts have, under the conditions employed, become practically constant in the solution. Any factor tending to change these relations will affect the current efficiency—for example, change of temperature, increase of acidity, change of concentration and the presence of catalytic agents, such as toluene or petroleum ether. In the ordinary problems of electrochemistry it is conceivable that in reducing from the higher stages of oxidation, that solution from which metal can be deposited may not be obtained. For this reason solutions in which the metal shows its lowest valency should in this and in all analogous cases be used when it is desired to obtain good current efficiencies in the deposition of metal. (In connection with this paper the Electrochemical Society paper of H. R. Carveth and B. E. Curry should be consulted, which was published on page 176 of our May issue.)

Electrolysis of Fused Cuprous Sulphide.—Since all attempts which have so far been made to win copper directly from the ores by electrolysis of aqueous solutions have been failures, G. Bodlaender (who recently died in the prime of life) and K. S. Idaszewski have tried the electrolysis of fused Cu_2S. Their results are given in *Zeit. f. Elektrochemie*, March 24. While the results are completely negative from an industrial point of view, they are scientifically interesting. The melting point of Cu_2S was found to be 1091° C. Hittorf's result that solid Cu_2S is an electrolyte and a very poor conductor of electricity at ordinary temperature, was confirmed; the conditions are, however, completely changed, if in Cu_2S some CuS is dissolved, which acts practically as a metallic conductor. The authors, in trying to electrolyze fused Cu_2S could not find any decomposition point on account of the dissolved CuS. Fused Na_2S is decomposed at 1.62 volts, fused K_2S at 1.65 volts; fused Na_2S and Cu_2S are to a limited extent miscible, since up to a certain concentration Cu_2S is dissolved in Na_2S, and reversely Na_2S in Cu_2S. The authors found a new compound, NaCus. If a solution of fused Cu_2S in fused Na_2S is electrolyzed, copper migrates in form of a complex anion to the anode; this is the first example of a complex anion in a fused salt. At the cathode copper is deposited by a secondary reaction. There are no prospects whatever of winning copper on an industrial scale by electrolysis of pure fused Cu_2S or of fused $Na_2S + x\%$ Cu_2S.

Alternating-Current Electro-Analysis.—Brochet and Petit, who have carried out several investigations on this subject, have published another paper in *Comptes Rendus*, Feb. 13, which is abstracted in Lond. *Elec.* of March 3. The authors analyzed certain organic acids by means of an alternating current and obtained a high efficiency. They used a test tube containing about 150 cc. of solution and ribbons of platinum as electrodes, the mean current density being 1 amp. per sq. cm. The solutions used included solutions of the formates of potassium and barium, and acetic and oxalic acids. With the potassium formates the results are extremely variable, and the electrodes are rapidly covered with a light deposit of carbon. The efficiency rapidly diminishes, and it is necessary to make the measurements quickly, and to calcine the electrodes after each experiment. The carbon obtained does not adhere to the electrodes, but spreads through the liquid and gradually falls to the bottom. The gas developed is nearly pure hydrogen, with a very slight admixture of oxygen and carbonic acid. The efficiency is 80 to 90 per cent. The barium formate gives about 65 cc. per minute of a mixture of hydrogen and carbonic acid, the efficiency being about 75 per cent. There is practically no oxide of carbon disengaged. The analysis is in every way similar to direct-current analysis.

Iron and Steel.

An Iron-Ore Cable Carrier.—Stahl und Eisen, of March 1, contains an illustrated description of the most active cable road in the world. It is a cable 10.75 km long, with a fall of 145 meters, uniting the blast furnaces in Kneutinger, Lorraine, with the mines, and built by the firm J. Pohlig, in Cologne. The buckets hold on an average 650 kg of ore; they follow each other at a distance of about 65 meters upon the cable, and run at a velocity of 2.5 meters (8 feet) per second. The grade is 1.70, and the friction is so small that the cable practically runs itself. Working two ten-hour shifts a day, the roadway furnishes about 1700 tons of ore per day, which runs four blast furnaces. In 300 working days the road furnishes 500,000 metric tons of ore, representing a yearly tonnage of 5.75 million ton-kilometers (3.5 million ton-miles). The loaded buckets pass over ore bins, into which they dump their load without being detached from the cable. The railway cost for this transport was formerly 1.20 marks (30 cents) per ton, while the total cost by cable is but 0.25 mark (6 cents). Further comment on the enterprise of our German ironmasters is superfluous; the iron industry is moving with gigantic strides all over the world.

The Fine-Ore Problem.—The difficulty of smelting powdered ore is not the exclusive property of American ironmasters; but foreigners are meeting and overcoming the same difficulty, and their experience cannot but be suggestive and, perhaps, useful to us. Director Zeidler, of St. Petersburg, describes in *Stahl und Eisen*, of March 15, a briquetting process which has been operated at Kertsch, in the Crimea, for several months, at a phenomenally low cost. The ore is a powdery limonite, carrying 42.5 per cent of metallic iron, 2.00 manganese, 1.25 phosphorus, 1.50 lime, 0.25 magnesia, 4.50 alumina, 15.00 silica, 0.07 sulphur and 11.00 water chemically combined, while the freshly mixed ore contains besides this 15 to 18 per cent of moisture. Such ore must be dried before briquetting, and for this purpose drying ovens were constructed similar to the Scott mercury roasting furnaces, or more like the Cermak-Spirek roasters, in which the ore falls over inclined shelves, while the heating gases pass transversely across the furnace under the shelves. These are run by waste gases from a group of 200 Coppee coke ovens, situated at a distance of 150 meters. In order to bring the gases that distance a novel arrangement was devised, well worth describing. The waste gases left the ovens at 1100° to 1200° C., and were sucked into a Körting air-suction apparatus, using cold compressed air at 0.25 atmosphere pressure. It was not desired to have the products of combustion coming to the drying ovens at over 500° or 600° C., and the suction apparatus was so proportioned that 150 cubic meters of compressed air drew away 500 cubic meters of hot waste gases, forwarding them with a pressure equal to 100 mm. of water column (2.5 ounces per square inch). Whatever unburnt constituents were in the gas were completely burned in the injector, which was lined with fire-brick, and the gases coming from it were at a temperature of 550° to 650° The apparatus furnished a total of 274 cubic meters of mixed

gases per minute, measured cold; the rest of the waste gases went, as before, to a boiler plant. The hot-gas flue, 150 meters long, was placed underground, with dimensions of 1.5 x 1 meter, and the fall of temperature to the drying ovens averaged only 50°. The gases left the ovens, with the 8 per cent of moisture extracted from the ore, at 60° to 100°, therefore giving a usefully applied heat of 78 per cent of their original heat. Each oven had a content of 10 cubic meters, and dried 80 to 120 tons of ore per day, down to 10 per cent of remaining moisture. The cost of this partial drying amounting to 0.46 mark (11 cents) per ton.

By drying the ore until it retained 10 per cent of moisture (aside from its chemically-combined water), it was found that it could be briquetted finely by simply powdering it over with fine lime (1.5 per cent of its weight) and putting through the press. Briquettes were made 100 mm. (4 inches) in diameter by 100 mm. high, using a pressure of 700 atmospheres tons, both above and below, the press furnishing 100 to 120 tons in twenty-four hours, using a 45-hp. motor. Experiments with ore of varying degrees of dryness showed that, using 500 atmospheres pressure, the strength of the briquette increased slowly, as the moisture in the ore decreased to 12 per cent; between 12 and 10 per cent of moisture the strength increased surprisingly fast, to a maximum, and then fell off just as quickly when less than 10 per cent of moisture was present. It is evident that with such ores, the moisture should be just sufficient to fill the pores between the compressed ore particles, and neither more nor less, to attain maximum strength by simple pressure. By acting on this principle, all burning was abandoned, the pressed briquettes being capable of standing a fall of 5 meters without breaking; they are carried direct from the press to the blast furnace. The total cost of sieving, drying and briquetting amounted in two months' running to 1.50 marks (37 cents) per ton.

Against this cost, the figures showing the running of the furnaces with raw ore and 80 per cent of briquettes in the charge are most striking. They are best shown by the deadly parallel column, in which I. is the original running, and II. the running with 80 per cent briquettes:

	I.	II.
Extraction of iron from ore.....	32.61%	39.68%
Output of pig iron daily.....	110.00 tons	185.00 tons
Tons of coke per ton of iron.....	1.48 tons	1.24 tons
Cost of charges per ton of iron.....	43.65 marks	40.03 tons
Manufacturing costs per ton of iron.	12.44 marks	6.46 tons
Total costs per ton of iron.....	56.08 marks	46.49 tons
Blast pressure	1.00 atmos.	0.50 atmos.

Besides these advantages there is not reckoned in, in marks and pfennigs, the sparing of brain fag to the management, caused by the avoidance of slips, explosions, flue dust and all irregularities to such a degree as to inspire Director Zeidler to say: "Der Betrieb was so ideal regelmässig, wie man ihn sich nicht besser vorstellen kann."

Mild Steel Castings.—The veteran iron metallurgist, Dr. Wedding, of Berlin, contributes to the March number of our esteemed contemporary, *The Iron and Steel Magazine*, a very clear presentation of "The defects in ingot-iron castings." Dr. Wedding's semi-official position in Berlin accounts for his using the term "ingot iron" to designate what not only we, but his own countrymen, call "mild" or "soft" steel, that is, cast steel which does not contain enough carbon to harden. The explanation is that the German government officially recognizes as "steel" only such varieties as can be hardened and tempered, and therefore it would be *iese majcste* towards the king of metals for a "Geheimer Bergrath" to use the term "soft steel." We think, however, that since *The Iron and Steel Magazine* is published in the English language, that "ingot iron" could have been more properly called "mild steel." Discussing the properties of such castings, their tensile strength is less than 50 kilograms per square millimeter (70,000 pounds per square inch), yet they possess greater strength than cast-iron castings, and are superior to the latter in being forgeable. Their chief defects are the enclosing of cavities, due to shrinkage or blow-holes from gases. Three kinds of furnaces furnish the melted material, viz.: open-hearth furnaces, converters and crucibles, the latter giving the best metal because its composition can be more exactly regulated, and it is capable of being made comparatively free from enclosed gases. To these Dr. Wedding will, in the next article he writes on this subject, be able to add the electric furnace, which combines the advantages of the crucible furnace with a cheapness which begins to rival that of the open-hearth furnace at certain localities. The defects in such castings are those due to (1) blow-holes caused by evolution of dissolved gases; (2) shrinkage cavities, caused by contraction of the melted interior after the outside has solidified; (3) air bubbles, caused by air mechanically carried into the melted metal during pouring; (4) steam cavities, produced by development of steam or other gas from the materials of the mould; (5) surface cracks, due to gas pressure arising from the steam or gas evolved by the moulding material; (6) cracks, caused either by contraction of the casting in the mould or by exposure to cold air when stripped too hot. The methods in use for avoiding these defects are discussed at length; it is to be regretted, however, that in describing the action of silicon and aluminium in preventing blow-holes, the distinguished author should still adhere to the discredited occlusion theory, viz.: that these elements in some mysterious way increase the capability of iron for holding gases in solution. Ledebur's de-oxidation theory, supplemented by Le Chatelier's beautiful explanation, has rendered the "occult" occlusion theory quite superfluous.

The article concludes with the methods of cure of such defects, as distinguished from the methods of prevention. They are: (1) Filling the cavities by electric welding; (2) filling by patching, *i. e.*, by welding in very hot pure iron; (3) filling by molten iron; (4) filling by "Thermit" treatment. The methods of cure are, in general, so unsatisfactory, that the metallurgist is strongly recommended to put his best efforts in the direction of prevention.

Case-Hardening.—Those particularly interested in this treatment of steel articles will find a good *résumé* of present information upon the subject in an article by David Flather in the April issue of *The Iron and Steel Magazine*, being a reprint from an English publication of 1903.

Iron Foundry Practice.—The same number of the journal just referred to contains a reprint of a very instructive paper by Mr. J. E. Stead, of Middlesborough, England, read before the Cleveland Institution of Engineers, Feb. 20 of this year. As the Transactions of that Institution are difficultly accessible, our readers interested in this subject will welcome the opportunity of reading this paper in full in our American contemporary. The following practical suggestions, however, are so entirely pertinent to every sort of metallurgical practice that we quote them here for the benefit of all of our readers: "(1) An analyst who has no metallurgical knowledge is only useful for supplying true analysis, but in that respect he is indispensable. (2) Foundries rarely have fully trained metallurgists to control the mixing and casting of metals. (3) If there is a metallurgist in the foundry he will be able to usefully apply the analyses provided by the analyst. (4) The primary essential is to have accurate analyses, and in making a selection a chemist should be chosen who has had a metallurgical training in a technical college. (5) It is a rare thing to find a chemist who has had practical experience in a foundry, and the founder must take the material available. (6) Having selected a man, his real training must begin on entering a foundry laboratory, and whether or not he develops into a useful metallurgist must depend largely upon his ability and capacity for gaining knowledge. (7) To facilitate this his employer should furnish every standard metallurgical treatise

containing useful data on foundry practice, a complete set of metallurgical journals and technical papers, and the analyst should become a member of the Foundrymen's Association and attend its meetings. (8) One of his duties should be to read everything published on foundry work, and to ensure that he does this he should supply periodically to the head or principal a review of the publications accessible. * * * (12) An analytical metallurgist in a works will be found as valuable in the conduct of the establishment as the secretary, accountant or the timekeeper."

RECENT METALLURGICAL PATENTS.

Copper.

G. Mitchell (788,589, May 2) patents the following process of treating silicious copper ore: He feeds into the smelting furnace any kind of copper sulphide, pyrites, or silicious ores in particular, after having finely crushed them and without roasting. He then subjects the ore, without the admixture of any carbonaceous or other fuel not already contained in the ore, to a sufficient degree of heat in a reducing atmosphere within the smelting furnace to effect fusing, admitting only sufficient air to support combustion and avoiding the presence of sufficient oxygen to cause a chemical union of the metallic portion with silica. Thus the metals of the ore will be fused, leaving the silica behind and unattacked by the metals. The advantages aimed at by the inventor are to avoid roasting and to save fuel, on account of no silicates being formed in the smelting process. The fused matte, minus the silica, is drawn off from time to time, and charged into a Bessemer converter.

Vanadium, Molybdenum, Titanium, Tungsten.

H. L. Herrenschmidt (787,758, April 18) patents the following process for treating vanadium ores, which is stated to be equally applicable for treating molybdenum, titanium and tungsten ores. The process consists essentially of three steps. First, the refining of a vanadate-of-soda liquor, obtained by treating the vanadium ore, or product, with a soda salt, either by evaporation and crystallization or by the addition of vanadic acid (which latter may result from a fractional precipitation obtained by the addition of vanadium sulphate, which may be impure), or of an acid or of a metallic salt.

Second, the precipitation of the vanadium contained in this purified liquor, either by means of the sulphate, chloride, or other soluble salt of a metal—such as iron, nickel, copper, etc., with the object of obtaining the vanadate of iron, nickel, copper, etc., respectively; or by the action of concentrated sulphuric acid upon the liquor previously concentrated to a syrupy condition, with the object of obtaining vanadic acid.

Third, the reduction of the oxygenated compounds of vanadium; the vanadates of nickel, iron, copper, etc., being reduced by carbon, tar or other reducing agent, to produce the desired alloy.

Nickel.

The important industrial problem of extracting the nickel from copper nickel matte is the subject of a patent of Hans A. Frasch (791,090, May 30). If copper-nickel matte, and particularly matte which has been concentrated by the Bessemer process, be subjected to the action of acids, like sulphuric acid or hydrochloric acid, the nickel sulphide in the matte is readily dissolved; but the nickel which is not combined with sulphur, dissolves very slowly if at all. To dissolve this insoluble, or sparingly-soluble nickel, it is proposed to finely pulverize it and mix it with sulphur and a solvent acid and apply heat.

Zinc.

The very low efficiency of our present zinc furnaces is well known. If the main features of our ordinary method of zinc reduction and distillation are to be maintained it is evident that, besides the important problem of retort construction, the chief possibility of improving fuel economy would be by means of a very uniform temperature in the furnace, just sufficient to reduce the ore in each retort in the allotted time. At present the Siemens regenerative retort furnace is limited in height to five tiers of retorts, and it is impossible to heat uniformly the different tiers of retorts. The lowest tiers are subjected to an intense heat, with the result that the ore in them is reduced more quickly than in the upper tiers. For this reason it is preferred to charge the upper tiers with the less refractory oxides or blue powder.

Herman Hegeler and Julius W. Hegeler (792,773, June 20) propose the construction of a regenerative retort furnace, shown in Fig. 1, in order to control completely the temperature throughout the full height of the furnace, so that the number of tiers of retorts is limited only by the draft and the practical height of furnace construction. For this purpose the inventors introduce the entire amount of the air at the bottom of the retort chamber under the lower tier of retorts, and provide an excess of air up to the top of the combustion-chamber, the gases being introduced separately from the air at different heights above the air-ports, to produce the combustion progressively as required, in order to heat all the retorts simultaneously and uniformly to the temperature required and reduce the ore in all of them at the same rate.

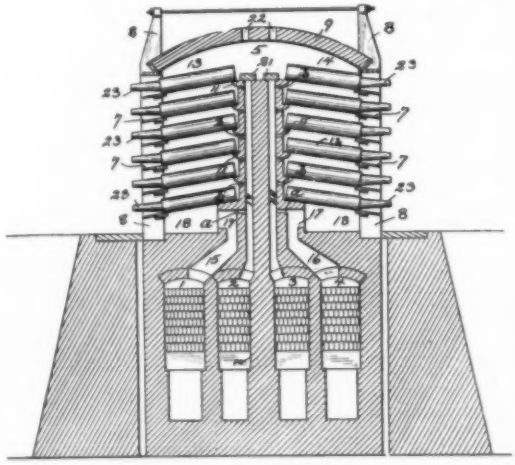


FIG. 1.—ZINC FURNACE.

The diagram is almost self-explanatory, when it is understood that 1 and 4 are air-regenerators, and 2 and 3 gas-regenerators. The flues 15 and 16, with their ports 17, are so constructed as to throw the entire volume of air into the lower part of the combustion chamber beneath the lowermost tier of retorts. Flues 19 and 20 are connected with the gas-regenerators 2 and 3, and extend straight up on both sides of the central division wall 10.

Iron and Steel.

N. McConnell (792,914, June 20) patents the following method of making open-hearth steel, the principal advantage claimed for the same being a reduction of the time of treatment. The inventor introduces molten pig metal into an acid-lined converter and blows air through it in the manner common in Bessemer practice, until the silicon is removed, the carbon considerably reduced (to about 1 per cent), and the temperature of the metal raised by the reaction to a point corresponding with that required for keeping it melted, notwithstanding its loss of carbon. The metal is now transferred from the converter into an intermediate regenerative furnace, in which a large body of such metal is held under the influence of heat. The final treatment of the metal is effected in basic lined open-hearth furnaces, into which charges of the molten metal are transferred from the intermediate furnace as they are required. For illustration, the intermediate furnace may hold from 200 to 300 tons of the desiliconized and partially-

decarburized metal, and the basic open-hearth furnaces in which it is finally treated may have a capacity of 50 tons. In the open-hearth furnaces the metal is treated with basic additions in the usual manner, the phosphorus is eliminated, the carbon reduced to the desired point, and the temperature of the metal is raised to the degree required for casting. The process enables the inventor to dispense with scrap, for the metal is rapidly desiliconized and partially decarburized before it is delivered to the open-hearth furnace, and the final operation in the latter is short.

J. Vernon (791,170, May 30) patents a "physic" to be introduced into the ladle before the molten steel in order to prevent blow-holes and piping. This physic contains in the condition of fine powder, ferromanganese and aluminium and refined silicious cullet, obtained either from native rock-crystal or from lead glass, which is comparatively free from lead and other metallic impurities. The cullet will yield silicon, and in melting will act mechanically upon the molten mass, besides increasing somewhat the temperature thereof. Other ingredients of the mixture are porous earth of a clayey or loamy nature, and what is known as "kelp," viz.: the calcined ashes of seaweed. The former, from its comparative lightness, will have a tendency to rise through the molten mass, thereby providing an escape for the occluded gases, which, if they remain in the metal, are the cause of the blow-holes. The kelp, properly dried and ground, contains sodium, potassium, carbon and iodin, and has the effect of decomposing the phosphorus and sulphur, which can then escape in the form of vapor.

BRIQUETTING.

E. Pohl (792,449, June 13) produces solid lumps from granular, or pulverulent, iron ores in the following way: The pulverulent ore is agglomerated by means of liquid slag, which falls down as rain or spray onto the ore and is intimately mixed with it. The process is carried out in a revolving retort. Finely divided, white-flowing liquid blast-furnace slag is used as binder where available; Thomas slag may also be used or molten iron.

W. A. Köneman (791,799, June 6) makes ore-briquettes for blast-furnace smelting by mixing together ore-fines and finely divided uncoked bituminous coals and anthracite coals, and adding to the mixture a binding agent (like lime or a lime mixture or gelatinous matter or slag), with or without a fluxing material. The mass is then formed into briquettes and dried without coking, so as to provide briquettes of mixed are and fuel for subsequent coking by the direct heat of the blast furnace.

J. Furnkawa (784,850, March 14) casts a shell of matte around a core or ball of fine ore, flue-dust and smalls of coke.

GOLD AND SILVER.

John A. Just (788,912, May 2) patents the following process of extracting gold and silver from ores: The ore is first subjected to a chloridizing roasting, and is then washed and introduced into the extraction vessel, which contains a calcium chloride solution, and into which chlorine is introduced at the bottom. The chlorine gas diffuses readily and auric chloride is formed, while the calcium chloride solution simultaneously dissolves the silver chloride. The solution is maintained in an acid state by a limited amount of hydrochloric acid. The solution goes into the precipitating tank, in which air is used for stirring, while the gold and silver are precipitated by means of metallic zinc. The solution is separated from the precipitate by a filter press.

MISCELLANEOUS.

S. Groh (783,429, February 28) patents details of construction of a regenerative furnace, the object being to bring both the gas and air at proper and equal temperatures to the point of mixture and combustion. For this reason the inventor controls the passage of the products of combustion through the conduits, so as to subject the checkerwork, through which the air subsequently passes, to the action of the major portion of the heat units of the products of combustion. Thus the cold air assumes in its passage a temperature approximating that of the gas at the point of mixture.

T. C. King (781,887, February 7) patents a system for the removal of slag from smelting furnaces. The slag is delivered to a certain kind of pit, where it is granulated by a stream of water The water is heated to the boiling point, and nearly half of the water is converted into steam. This heat is utilized for heating or power purposes, while the ganulated slag is delivered to an endless conveyor.

M. Murphy (783,535, February 28) patents details of construction of an elliptical smelting furnace. Its roof is arched and its ore-bed is an inverted arch, having its ends extended into the side walls of the body of the furnace. Stay-bars extend longitudinally through the body of the furnace below the ore-bed and support the same, while other stay-bars are arranged against the outer sides of all the walls of the furnace; extensible connecting rods securing the stay-bars.

C. M. Gunn and W. D. Mulloy (782,334, February 14) patent details of construction of a hot-air blast stove for supplying heated air to smelting furnaces. The air tubes are so connected as to distribute the strains of contraction and expansion uniformly throughout the series. The end tubes of each series are connected with end boxes for receiving the cool air and delivering the same to the feed-tube of each series, and the hot air from the discharge tubes and delivering the same to the supply pipe for the heated air.

F. L. White (783,234, February 21) patents details of construction of hot-blast stoves. They consist essentially in an improved arrangement of supporting arches in the lower regenerative chamber, while the regenerative passages between the upper and lower regenerative chambers are formed in a body of novel checker-brick laid so as to break joints and present a bonded structure.

L. de Rome (782,438, February 14) patents details of construction of foundry furnaces, the principal object being the utilization of fuel-oils in the melting with its consequent saving of time and fuel. A depressed inclined hearth is surmounted by a dome, and with an outlet for the products of combustion. An oil-burner has its flame directed against the metal piled upon the hearth, while a well contains a crucible beneath the drip from the hearth. A second oil-burner has its flame directed around and about the crucible.

L. O. Brightbill (783,413, February 28) cools the walls of a furnace by spreading cooling water from a trough mounted on the wall, in a continuous film over the surface.

G. L. Davison and D. R. Mathias (783,778, February 28) patent details of construction of a water-cooled arch particularly adapted for use, in conjunction with open-hearth furnaces.

J. Reuleaux (782,697, February 14) patents details of construction of a continuous heating furnace for heating billets; J. H. Vinton (782,888, February 21) details of construction of a furnace for heating toe-calk blanks.

J. T. White (782,298, February 14) patents details of construction of a spout for blast furnaces. The spout comprises a hollow shell provided in its outer side near one end with a plurality of water-inlet supply openings arranged in alinement and longitudinally with the spout, and near the other end with a water-outlet opening; heads are detachably connected with the shell. The object is to increase the life of the spout and facilitate repairs.

A. R. Brink (780,592, January 24) patents details of construction of a spout, comprising a number of water-jacketed, self-contained detachable sections joined together; each section is supplied with water independently of the others.

S. Peacock (781,546, January 31) patents details of construction of a gas-seal for rotary roasting furnaces; W. Stubblebine (782,082, February 7) details of construction of a rotary puddling or busheling furnace or a furnace for treating scrap metal.

BOOK REVIEWS.

The Theory of the Lead Accumulator. By Dr. F. Dolezalek. English translation by Dr. Franz L. von Ende. New York: John Wiley & Sons. 241 pages. Price, $2.50.

Prof. Dolezalek's German monograph on the theory of the lead accumulator is undoubtedly the best and most up-to-date book on the subject. While essentially a concise theoretical treatise, we believe it has, nevertheless, exerted a healthful influence on storage battery engineering. It has brought home to the practical man forcefully the enormous importance of perfect diffusion of the acid into the pores of the active mass, although this point of view has apparently been pushed a little too far in a few instances in the book. The main reason, however, why this book has been received so very friendly, and even enthusiastically, by the electrochemical public at large, is that it is the only work in which the modern theories of solution and the dissociation theory have been applied with strict consequence to a single practical engineering problem. While not pretending to teach theoretical electrochemical principles, yet it is in effect the best book which electrochemical engineers may take up to become acquainted with the theory. In this respect it is a little masterpiece.

It is gratifying to have the book now issued in an American translation. The translator has accomplished his task carefully and faithfully. But there can be no doubt that in some small details his faithfulness towards the original German manuscript goes too far. One understands why in the original German book the reader is referred to a German translation of Gladstone and Tribe's English paper. But it would seem almost ridiculous that in the book before us (page 2), which is intended for American readers, again the German translation is referred to, and the original English paper is not mentioned. In the enumeration of books on storage battery engineering in the preface, Mr. Lamar Lyndon's well-known book—certainly the best book in English language on this subject—should not have been omitted. In a few instances the translation of special technical terms is too literal. "Degree of efficiency" (page 174) and "working efficiency" (page 175) are certainly unfortunate. In the whole, however, the translation is careful and reliable.

Lifting Electromagnets in the Iron and Steel and in the Tin Industries.

Electromagnets have in the past been mainly used for creating a magnetic field, as in dynamos and motors, while the simplest application of an electromagnet, namely, for lifting purposes, was usually limited to small scale operations, to instruments and to work in the laboratory. However, this situation has been completely changed in recent years, and the lifting electromagnet is now an important piece of machinery in modern iron and steel works.

This development is essentially due to two leading tendencies in modern manufacturing methods: to push the output of a plant to the utmost, and to reduce as much as possible the number of workingmen. The first requirement is fulfilled by a lifting electromagnet on account of the simplicity of its action: it is lowered on the piece or pieces to be lifted, the switch is closed and the magnet is thus instantaneously energized, the load is hoisted and transported; the switch is opened and the load thereby instantaneously released. This means that all the time is actually spent in hoisting and transporting; no time is lost as with chains where the piece must be barred up and the chains attached and adjusted, and later on must be released. With the lifting magnet the attaching of the iron masses to the magnet, and afterwards their release are essentially automatic and instantaneous. All the heavy work is done by the electromagnet and crane. This explains why only a single workingman is required for most cases. He has nothing to do but to close and open the switch of the electromagnet and attend to the crane. Only in such cases where several pieces as billets are to be carried at each lift, a ground helper is required to adjust the several pieces.

The Electric Controller & Supply Co., of Cleveland, Ohio, has made a specialty of the design and construction of such lifting electromagnets, and their magnets are the result of years of experience in this field. The case is a heavy casting made from such a grade of steel that when the circuit of the energizing coil is opened the magnet drops its load instantly, so that no time is lost. The energizing coil is form wound, heavily insulated and treated by a vacuum impregnating process which insures it against grounding, or short-circuiting. The coil is completely enclosed and protected by the case, which is ribbed to provide for rapid radiation of the heat of the coil. The current is led to the coil through a heavily guarded plug connection. This plug is simply pulled out when it is desired to detach the magnet from the crane hook.

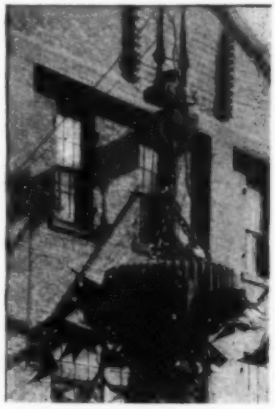


FIG. 1.—LIFTING MAGNET FOR TIN SCRAP.

These lifting magnets are suitable for handling pig-iron, steel or iron scrap, bolts, billets, blooms, slabs, or cold ingots

FIG. 2.—HANDLING IRON AND STEEL SCRAP.

in quantities, rails, pipes, sheets or other special shapes in quantities or under special conditions. The "pig magnet" of the Electric Controller & Supply Co. is made in two sizes; the smaller size handles an average of 500 pounds pig iron per lift; the larger size from 1100 to 1400 pounds. These magnets are particularly efficient for such material which can be handled direct from the car to the regular open-hearth charging-boxes, or to the stock pile. They are also very suitable for handling light melting stock, shearing scrap, rod scrap, bolts,

nuts, punchings, rivets, spikes, etc. This class of material is very difficult to handle by hand. It cannot be shoveled and is very slow and costly work where a fork is used. It is light

FIG. 3.—HANDLING BUNDLES OF IRON WIRE.

and easily and quickly magnetized. The larger type of magnet is especially useful for unloading or loading cars with pig-iron billets, scrap, etc. The time required to load or unload with lifting magnets in such cases will vary from one to two minutes per ton, depending almost entirely on the skill of the crane man and the amount of crane travel required, as practically no time is required to attach or release the load. Iron or steel turnings or borings, scrap, bolts, rivets, punchings, or similar small scrap, so difficult to load or unload by hand, are handled at a rate of 600 to 1200 pounds per lift by the larger type of "pig magnets," as is shown in Fig. 2. The handling of bundles of iron wire by lifting magnets is shown in Fig. 3.

The lifting magnets are now also playing an important rôle in the tin industry for the reason that on account of the limited supply of tin ore the electrolytic detinning of tinned iron scrap ("tin cans" for preservers, etc.) has become a profitable industry. The handling of tin scrap by the lifting magnet is shown in Fig. 1.

Producer Gas Plants in Scotland.

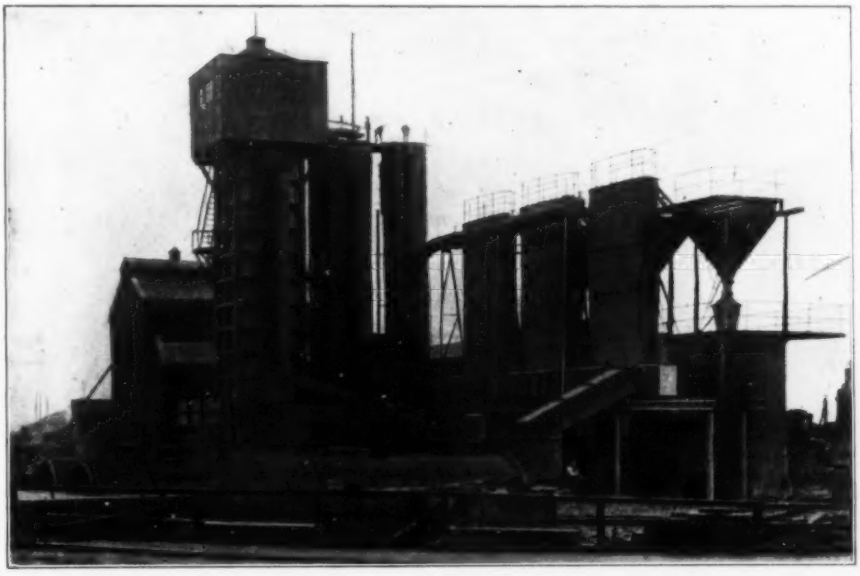
With reference to an article of Mr. F. C. Perkins in our February issue (page 85), we have received some notes by Mr. Edward J. Duff, of Duff Brothers & Co., Liverpool, referring especially to the Parkhead Steel Works, of William Beardmore & Co., Glasgow. Mr. Duff states that this producer gas plant was erected to his patents, designed and started into operation by himself, and is entirely a Duff gas installation. Some further notes concerning this plant may be of interest.

This plant was the first teel plant in Scotland in which the recovery of ammonia from the fuel has been undertaken. Initially, only five producers were installed, but they proved so successful that there are now 10 producers in operation at the Parkhead Steel Works. The gas is used for steel melting, for making large forgings for guns, shafting, etc., up to 60 tons weight, for the manufacture and treatment of armour plate, and in the running of a number of large gas engines, some of them 1000 horse-power each. Another installation, first with 3, and later with 5 producers, is now successfully at work at William Beardmore & Co's large, new shipyard at Dalmuir on the Clyde, which was also installed by Mr. Duff. The first installation, containing 3 producers, is shown in the adjoining illustration. The bulk of the gas is used in gas engines of the Oechelhaeuser type, built by Messrs. Beardmore & Co. themselves. The gas engines drive dynamos for the supply of electric power. Both plants burn Scotch bituminous slag, a very cheap fuel.

A brief description of the operation of the plant should be of interest.

The coal is brought into the works in wagons, from which it is tipped into a large boot receiver below rail level. By means of a chain-and-bucket continuous elevator, it is raised to an upper platform above the producers. Along this platform the coal is conveyed and dropped at will into any one of the storage hoppers provided for each producer feed. The coal is shot as required into the producers through gas-tight trap-boxes.

The gas issuing from the producers is partly cooled by passing through a regenerator by which a portion of the heat is transmitted through tube surfaces to the incoming air and steam. The incoming air and steam are fed to the superheaters through the pipe shown near the top of the oval-shaped chambers above the producers; they leave them near the base and pass through a pipe to the blowing chamber of the producer below the fuel bed. The superheaters are provided with dust separating boxes, and the same is the case with the rectangular gas main, which is shown in front of the base of the superheaters, and into which the gas passes from the superheaters. The gas then passes down the connecting pipe into a scrubber on the ground level, where it meets with



GAS PRODUCER PLANT.

a shower of water whereby any soot or remaining dust are removed from the gas and also a portion of the tar.

The gas then passes into the ammonia tower which is the square tower shown at the left of the illustration. Here the gas passes upward through a shower of sulphuric acid liquor, and ammonium sulphate is formed, from which the commercial crystal sulphate of ammonia is derived by subsequent treatment. After leaving this tower the gas is cooled with water in the "gas tower;" it is then put through a centrifugal washer and a saw-dust scrubber, and is then ready for use in the gas engines.

The third tower in the row is the air-heating tower in which the water heated by cooling the gas in the "gas tower" is again cooled by incoming air and made ready again for the purpose of cooling gas. The plant is thus recuperative for both heat and water. The air then passes from this tower to the superheaters and the gas producers as already described above.

The American representative of Messrs. Duff Brothers & Co., is Mr. A. B. Duff, 4716 Maripoe Avenue, Pittsburg, Pa.

Metallographic Equipment of Laboratories.

The enormous industrial importance of high-speed tool steels has been the reason for attracting in recent years the attention of numerous investigators to a systematic research of ferro-alloys and of alloys in general. In this research the limitations of chemical analysis were soon recognized. It is now clearly understood that "chemical composition is not everything," *i. e.*, that the properties of a "solid solution" depend not solely on the chemical composition, but to an important degree on the previous history and treatment. Of course, the effect of annealing or tempering of steel has long been perfectly known. But the reason why the physical properties of metals, especially of alloys, depend on the way in which they were cooled from the state of fusion, has only been recognized in recent years, when the microstructure of alloys was systematically investigated and considered and viewed in the light of the phase-rule. The experimental research was made possible by the fact that if a hot metal is suddenly cooled by chilling it in cold water, its microstructure at the high temperature is fixed and preserved by the sudden chilling, so that it may be afterwards examined in the cold metal by polishing and etching it in the usual manner. Some general principles of metallography were given in an article by Dr. Wm. Campbell in our February issue, 1904.

In view of the importance of the subject, a brief description of the new metallographical equipment of the Institute of Technology, of Aachen, Germany, should be of interest. This institute has lately taken up metallography in its official plan of instruction.

The grinding of the specimens intended for examination of the microstructure is done, according to the most universal practice in Germany, on rotating triplex cross-glued wooden discs, pasted with the best emery paper. The following numbers are successively employed: 3, 2, 1G, 1M, 1F, 0, 00, 000, 0000. Then the specimens are polished with finest jewelers' rouge on a disc covered with cloth.

The entire microscopic and microphotographic equipment, except, perhaps, one microscope stand, came from the shops of the firm of Carl Zeiss, of Jena. This microscope stand serves in connection with the lower power lenses for the preliminary investigation of the ground specimen, which quickly and conveniently follows the course of the grinding, polishing and etching.

For close examination of the prepared specimens, as well as for photographing them, the microphotographic apparatus is used. It consists of a Martens microscope with illuminating arrangement and photographic camera. They are placed separately on iron brackets, bedded in the wall, so as to prevent vibrations, which is an absolute requisite to get sharp photographs with the stronger objectives.

The strongest magnification is, for direct observation, 1000, and for photographs with the sensitive plate 1 meter away from the eye-piece, 4000 diameters.

The construction of the Martens stand is shown in Fig. 1. Externally it differs from the ordinary form through the horizontal, instead of vertical, position of its optical axis. The tube, moved by wheels, carries an extension tube provided with a millimeter graduation for setting it at the length prescribed for the several objectives. The collar is slipped on the holder of the eye-pieces, and in photographing, forms the opaque coupling of microscope and camera; actual contact between them is, however, avoided. The shell on the camera, when brought up to the microscope, enters the collar.

If the stand is to be used for photographing without eye-piece the extension tube is entirely removed and replaced with a so-called light-excluding shell, which may likewise be given a light-proof connection with the camera without touching it. This light-proof shell is shown on the Martens stand in Fig. 1. The objective can be given a rapid movement by the wheel, or a fine one by the micrometer screw. On the latter a travel of the table as small as 0.005 mm. (0.0002 inch) may be read directly. The stage for mounting the object is revolvable, and can, by co-ordinate drives, be moved in two mutually perpendicular directions, thus permitting a systematic examination of the specimen. Since it is generally necessary to mount the

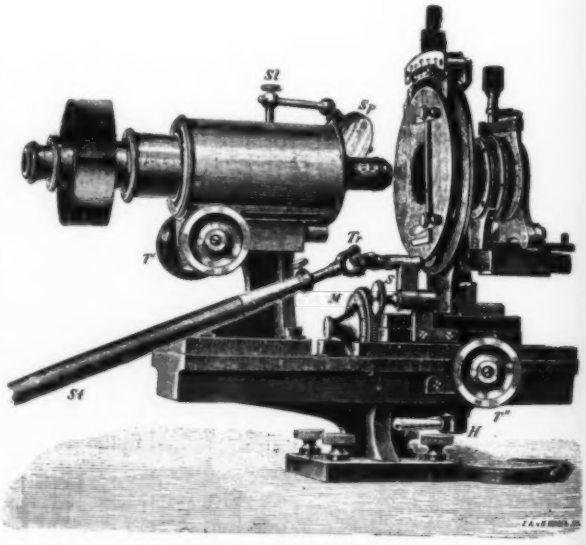


FIG. 1.—MARTENS STAND.

object exactly perpendicular to the axis of the microscope, there is placed on the stage proper a second, smaller, stage parallel with it and furnished with adjusting screws, by means of which an exact position may be quickly and positively given. The specimen, glued to a glass slide with a mixture of rosin and beeswax, is held against the smaller stage with screw clamps.

The illumination, which in the case of metal sections, as with all opaque objects is by superficial light, is secured by the movable mirror shown in the illustration, or a thin, flat glass, so arranged that the day or lamp light falling perpendicular to the optical axis is reflected upon the specimen. Since this method of lighting is applicable only with objectives whose distance from the specimen is sufficiently great, resort is had in case of the stronger dry systems, as well as of the homogeneous immersion lenses, to the so-called vertical illuminator, which is inserted between tube and objective. From a side window before which, by means of pins, an iris

diaphragm may be put up, the light falls on a little prism, by whose hypothenuse face it is totally reflected through the objective to the specimen.

A scheme of the lighting arrangement used with the vertical illuminator is as follows: The rays coming from the source of light—in our case a self-regulating arc lamp—pass through a compound lense system, consisting of the double lense part and a single lense part, and fall on the window of the vertical illuminator. Between the double and single lenses is inserted a water chamber for the absorption of the co-called "heat rays" having great wave-lengths. For reducing the field of vision there is an iris diaphragm.

For examining and photographing larger objects, broken pieces, etc., where high magnification is not needed, but facility of adjustment is desirable, the binocular coarse-work stand of Braus-Druener is used, Fig. 2. This also is a Zeiss instrument.

The apparatus, mounted on a heavy rectangular bed, with three rack and four swiveling movements, is adapted to the systematic inspection of large irregular bodies, wherein the comparatively long distance from the object is of advantage. Further, by means of the stereoscopic camera, interchangeable with the double tube, this stand performs a very valuable service, and can best be appreciated in that connection. In direct examination with the lenses provided, a magnification of 10 to 65 diameters is attained, and in photographing with the stereoscopic camera 1.6 to 6.2 diameters. The depth of the sharp picture necessary to produce the idea of solidity varies, according to the degree of magnification, from 5 to 10 mm. (0.2 to 0.4 inch).

Finally, must be mentioned an apparatus employed for manifold metallographic services—the tube furnace. The Institute for Iron Metallurgy has for many years employed almost exclusively the Heraeus electric furnace, in which the heating

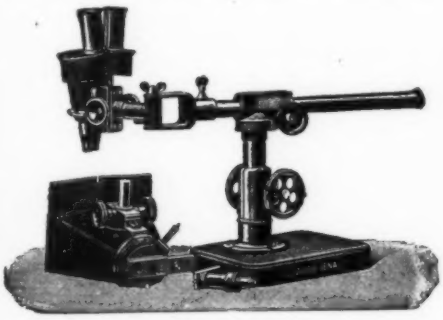


FIG. 2.—BRAUS-DRUENER STAND.

resistor consists of platinum foil 0.007 mm. thick, which is wound in spiral form on a Marquardt tube. These furnaces are notable for swift, certain and regular service, and are to-day so improved with suitable heat-guarding arrangements that, for example, in a furnace 500 mm. (19.7 inches) long and 30 mm. (1.18 inches) broad a temperature of 1450° C. can be continuously produced without fear of the foil burning through. Naturally, for furnaces of large section the high temperature permissible for continuous experiments is somewhat less.

Water-Power Development in Wisconsin.

The Rhinelander Power Co., of Rhinelander, Wis., composed largely, if not entirely, of local parties, has completed arrangements to develop the water power of the Wisconsin River at a point about 6 miles below the city of Rhinelander. A dam will be built, giving a head of about 24 feet, and sufficient water is obtainable to develop an average of about 600 hp. In the rainy season more than 2000 hp., at a conservative estimate, is obtainable.

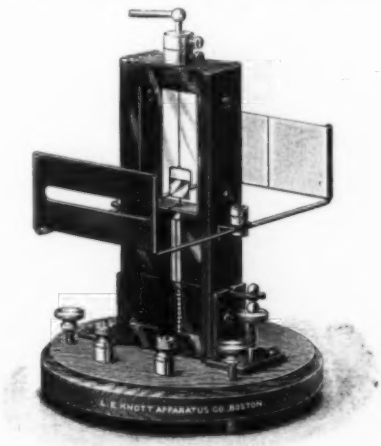
The Allis-Chalmers Co. will furnish the entire electrical equipment, which includes three 400-kw, 1100-volt, three-phase, 60-cycle generators, with three 70½-kw, 120-volt separately-driven exciters, six 150-kw, 10,000-volt transformers and complete switchboards at both the generating station and the sub-station at Rhinelander.

The current will be carried at 11,000 volts over a single three-phase circuit to the sub-station at Rhinelander, a distance of about 6½ miles, and from this sub-station will be distributed at 1000 volts for illuminating purposes, both commercial and street lighting, and also at 440 volts to the mill of the Rhinelander Paper Co. and other industries in the neighborhood of the sub-station.

This plant is one of the first long-distance transmission plants on the Upper Wisconsin River. It is expected that many more enterprises of a similar character will be undertaken in that region within the next two years.

Galvanometer.

The adjoining illustration shows the W-K, No. 2 d' Arsonval galvanometer, made by the L. E. Knott Apparatus Co., of Boston, for use in schools. The sensibility is 20 megohms. It is dead-beat, coming to rest after only one swing through the zero. Special points of the design are the scale attach-



GALVANOMETER.

ment (reflecting non-parallax method), the strict proportionality of the scale, and the accessibility and visibility of the moving parts, since glass slides on front and back render all parts visible and accessible. On account of the open construction no special illumination is required.

Industrial Notes.

The J. T. BAKER CHEMICAL Co., of Easton, Pa., has issued its first price list of c. p. chemicals. An important innovation is to print an exact statement of the analysis on every bottle containing a "c. p." chemical. The company has a New York office at 164 Front Street, and will be represented by the Chas. E. Sholes Co., Manufacturers Agents.

COAL HANDLING MACHINERY.—The C. W. HUNT Co. has issued a profusely illustrated pamphlet on coal-handling machinery for power stations, boiler rooms, coaling stations, gas companies, coal yards, shipping docks, manufactories, etc.

NICKEL STEEL.—The INTERNATIONAL NICKEL Co., 43 Exchange Place, New York City, has issued a pamphlet on "The Applications of Nickel Steel." It is an alphabetical index of

the various applications which nickel steels, containing 3 to 45 per cent nickel, have found in this country, France, Germany and England. "The addition of 3 per cent to 4 per cent of nickel to steel increases the proportional elastic limit, adds to the ductility of the steel, increases its resistance to compression, increases its resistance to abrasion, increases its resistance to shock, and increases its toughness. Nickel steel is, therefore, a safer material than carbon steel."

Manila Rope.—The C. W. Hunt Co., of West New Brighton, S. I., N. Y., have issued a very neatly printed and illustrated pamphlet on manila rope transmission and hoisting, the author being Mr. C. W. Hunt, who has long been recognized as one of the highest authorities on the subject. The pamphlet is far more than a mere trade catalogue, being, in fact, a concise treatise on the subject, with much useful information for engineers. The pamphlet begins with a description of the construction of manila rope. This is followed by an account of the use of ropes for power transmission, rope-driving diagrams and a table and diagram for the horsepower of transmission ropes at various speeds being given. Then follow notes on splicing and coupling of transmission ropes, knots, hitches and bends. A short account is then given of the use of ropes for hoisting. The appendix contains reprints of two papers, presented by Mr. C. W. Hunt on rope driving and on working loads for manila rope, before the American Society of Mechanical Engineers, and some shorter notes, among them a United States Navy test, showing 14.6 per cent less friction for stevedore rope than for ordinary three-strand manila rope. The stevedore rope is a special manila rope, made by the C. W. Hunt Co., in two types, for power transmission and for hoisting respectively.

Hard Rubber for Chemical Purposes.—We have received from the American Hard Rubber Co., 9 Mercer Street, New York City, their illustrated catalogue on hard rubber pumps, pipes, fittings and other utensils for chemical work. As is well known, hard rubber is used with acid and alkaline solutions, which either corrode metal or are contaminated by contact with it. In many cases the use of hard rubber has solved that ever-present and fundamental problem in wet processes—to keep the solutions clean, since, as was once said, everything may be accomplished with pure solutions, nothing with foul solutions. In hard rubber pumps all the parts which come in contact with the liquid are made of hard rubber; these are held by and mounted on iron parts, which take all strain other than internal pressure, due to head of discharge. The iron plate can be bolted to any suitable base. The company manufactures hard-rubber double-acting pumps, either with steam drive or with belt drive, or directly connected to electric motors, and single-acting hand pumps or power pumps. The variety of purposes to which hard rubber is applicable is shown in the catalogue by illustrations of hard rubber pipes (made in sizes from ½ to 4 inches), hexagon couplings, angle couplings or bends, elbows or quarter bends, tees, nut unions, caps, lock nuts, plug cocks with screwed socket ends (all in sizes from ½ to 4 inches), plug cocks with nipple ends for hose or threaded (½ to 2 inches), plug cocks, bibb ends, nipple end for hose or threaded (½ to 1 inch), air cocks (¼ inch opening, ⅛-inch iron pipe thread), buckets (1, 2, 3 gallons), mugs (1 pint), measures (1 pint, 1 quart, 2 quarts), ewers (2 quarts), funnels (⅛ pint to 1 gallon), floats (3¼ to 7 inches), dipping baskets and bottles for hydrofluoric acid (½ to 16 ounces). An interesting and apparently new application of hard rubber was recently mentioned in this journal (our June issue, p. 221), namely, for filter press linings and cocks.

We have received from the International Instrument Co., of Cambridge, Mass., a set of illustrated pamphlets on laboratory instruments made by this company. Among them are chronographs, laboratory clock, galvanometer lamp, absorption brake (for testing small high-speed engines and motors), absorption rheostat (liquid), Johnson cement testing machine (for determining the tensile strength of cement), distributing switchboards, adjustable laboratory stand (for general work, but especially useful where electrodes have to be immersed in and then withdrawn from solutions), Ferguson rain gage, several types of centrifuges, characterized by high-speed and large bucket capacities, primary batteries (closed circuit type: Excello battery; open circuit type: Samson, Nosmas and Columbia batteries), secondary batteries (chloride accumulator).

Messrs. Queen & Co., of Philadelphia, have issued a new circular, No. 1204, on condensers and self-induction apparatus. This circular shows a wide variety of condensers, from the most elaborate standards down to the small tin-case condensers used extensively in telephone work. Standards of self-induction, both fixed and variable types, are illustrated and described. Curves are also given, showing the absorption and leakage in the standard condensers made by this company.

Water-Power Equipment.—The Wellman-Seaver-Morgan Co., of Cleveland, Ohio, has issued an illustrated pamphlet on water-power equipment for low heads. The installations of this company for heads up to 100 feet embody the Jolly-McCormick turbines, which are furnished in a variety of settings and combinations, some of the most common of which are as follows: Single vertical setting in iron, single horizontal setting in iron, double horizontal setting in iron casing, with one or two inlets and one or two discharge openings; horizontal setting with any number of wheels on shaft, and variable arrangement for discharge; double vertical setting with turbines located above each other. The exact form of installation depends, of course, on local conditions, such as head, speed of flow, power required, contour of ground on which the plant is located, etc. In this respect a table at the end of the pamphlet should be very useful, summing up in eighteen questions the most important data which are required to decide on the best form, and give an estimate of the cost of the installation. The main part of the pamphlet gives illustrated descriptions of standard vertical cylinder-gate wheels; a form of balance gate with which the regulation is secured by adjusting the opening of the chutes or gates as required; construction of standard runners, and design of standard horizontal single turbines, as well as of various types of special horizontal turbines. On four pages complete power tables of the standard turbines of the Wellman-Seaver-Morgan Co. are given, based on tests of the whole series of nineteen patterns for fifty-two different heads between 4 and 100 feet; speed in revolutions per minute, water and horse-power are given for each of the nineteen patterns and each of the fifty-two heads. The efficiency is between 80 and 86 per cent.

The Leeds & Northrup Co., of Philadelphia, has just issued the second edition of their profusely illustrated catalogue of their electrical measuring instruments, for which they received a grand prize at the St. Louis Exposition. The catalogue covers condensers, galvanometers, slide wire or meter bridges, Carey Foster bridge, resistance standards, apparatus for measuring low resistances, standard resistance boxes, rheostats, Wheatstone bridges, standard high resistances, electrodynamometers, self-induction apparatus, portable testing sets, cable testing apparatus, cable splicers and lineman's fault finders, potentiometers, photometers, curve tracers, high-frequency apparatus and induction coils.

We have received from Messrs. Wm. Gaertner & Co., of Chicago, three illustrated catalogues. One deals with interferometers and accessories; the second with instruments of precision, laboratory apparatus and astronomical apparatus; the third with universal laboratory supports for manifold purposes.

Circular 1104 of the Westinghouse Electric & Mfg. Co. deals with portable instruments, voltmeters, ammeters and wattmeters for direct and alternating current, power factor meters and portable testing transformers.

SINGLE-PHASE VAPOR CONVERTER FOR CHARGING STORAGE BATTERIES.—The Cooper Hewitt Electric Co. has issued bulletin No. 8, describing the mercury vapor converter for charging small storage batteries from a single-phase alternating-current supply. The action of the converter is well understood from the behavior of the mercury vapor lamp. The "type PA" converter provides, in its present standard design, for 30 amps. direct current, and a d. c. voltage of from 80 to 115. Special outfits adapted to give d. c. voltages lower than 80, or exceeding 115, and not over 240, can be supplied. The converter is supplied for any single-phase a. c. supply voltage between 25 and 150 cycles. In case the a. c. supply does not exceed 450 volts, an auto-transformer is used for adapting the a. c. voltage to the outfit. On higher voltages a step-down transformer with a special secondary winding is used.

ELECTRIC DRIVE OF MACHINE TOOLS.—The Crocker-Wheeler Co., of Ampere, N. J., has published as bulletin No. 58 a well-illustrated, concise treatise on the individual motor drive of old machine tools, the author being Mr. R. V. Wright. After a brief discussion of the problem, the application of the electric drive to various machine tools is discussed in detail.

AGATE-SHELLAC.—Under this name a new shellac has recently made its appearance in Europe, and is now being introduced in this country by Mr. Felix Hamburger, 90 William Street, New York City. While being used for many purposes it is stated to be specially applicable as an insulating lacquer for electrical engineering purposes. According to tests of the German Reichsanstalt, in which the agate-shellac was compared with ground Indian shellac, the insulation resistance with agate-shellac was found to be from six to nine times greater than with Indian shellac, while the perforating voltage is slightly lower. It is stated that the Siemens-Shuckert Co. has adopted the shellac for use in their works.

BIG CRANK SHAFTS.—The BETHLEHEM STEEL CO. is at work on three crank shafts which will weigh 86,600 pounds each when finished. They are turned out of solid steel ingots, 25 x 4 x 4 feet, and are intended for three Snow gas engines, which are to drive 4000-kw Crocker-Wheeler alternators, the largest gas-engine-driven generators ever built, ordered by the California Gas & Electric Corporation.

VANADIUM.—We have received from the VANADIUM ALLOYS CO., of New York City, a pamphlet giving the results of extensive tests of vanadium steel, carried out by Messrs. Williams & Robinson, Queens Ferry, England.

The FRENZEL SMELTING & REFINING CO., of Denver, Col., is shortly to be incorporated under the laws of the State of Colorado. The erection of the plant will be started in about four weeks, with a capacity for treating 50 tons of ore per day at the start, while an extension to 100 tons per day is planned for the future. The output will consist of alloys of vanadium, tungsten, uranium, molybdenum and titanium, for use in the steel, cast iron, aluminium and copper industries. Electric furnace processes will be largely employed. Mr. A. B. Frenzel, Equitable Building, Denver, Col., states that he will be glad to correspond with parties with respect to improvements in the reduction of rare elements from the ores.

The Tacoma Smelting Co., Tacoma, Wash., has ordered from ALLIS-CHALMERS CO., of Milwaukee, a steel water-jacketed blast furnace for treating copper ores, the dimensions of which are to be 42 x 160 feet at the tuyere line. It will be provided with a specially designed tuyere box, which, it is believed, will prove more satisfactory than any tuyere box yet constructed.

The Sociedad de Minas y Fundiciones, Carrizal, Bajo, Chanarcitos, has ordered from ALLIS-CHALMERS CO., of Milwaukee, the complete equipment for a 50-ton copper smelting plant, to be erected at Carrizal, Bajo, Chili, South America. The installation will include a blast furnace and blower, with auxiliary apparatus, and a Bullock type "B" generator to supply current for an electric light plant. Mr. William M. Martin, the manager of the Chilian company, was in Chicago recently for the purpose of purchasing this machinery.

The Arizona Smelting Company has ordered for its plant at Prescott, Ariz., the complete equipment for a sampling mill. The contract also calls for an electrically-operated converter and two reverberatory furnaces with auxiliary apparatus. This very large order is another indication of the increasing activity in the copper fields of the Southwest. The entire equipment will be furnished by ALLIS CHALMERS CO., of Milwaukee.

We received from THE MINE & SMELTERS SUPPLY CO., of Denver, Col., a voluminous and profusely illustrated, complete catalogue of machinery and supplies. In spite of the conciseness and brevity of the descriptions of the various machinery dealt with, the catalogue contains 891 pages. This already indicates the completeness with which the mining and metallurgical field is covered. The catalogue is divided into nine principal sections, dealing respectively with the following subjects: Engines, boilers and feed-water heaters, hoisting engines, pumps, water-wheels and hydraulic machinery, mining, milling and smelting machinery, tools and supplies, assayers' supplies, electrical machinery, iron and wood-working machinery, ready reference tables and useful information. As an example the contents of the fourth section, devoted to mining, milling and smelting machinery, and covering 114 pages, may be briefly summarized. There are given in this section concise illustrated descriptions of air compressors, rock drills, crushing and grinding machinery, samplers, elevators, screening machinery, ore feeders, classifiers, concentrating tables and jigs, amalgamated fans, settlers, clean-up pans and barrels, amalgamated sieves, chlorination barrels, steel tanks, furnaces, lathes for making zinc shavings, cyanide process machinery, ore cars, conveyors, aerial wire rope tramways, dryers, roasting furnaces, smelting furnaces, etc. The book is concluded by a very useful alphabetical index covering 30 pages.

The NEW CASTLE PORTLAND CEMENT CO., New Castle, Pa., has placed an order with ALLIS-CHALMERS CO., of Milwaukee, for four rotary kilns, each 100 feet in length and 7½ feet in diameter at the large, and 6½ feet at the small end. These kilns, which will have a large capacity, are of extra heavy design throughout, and when completed will represent the highest type of machinery of this class in use. The tendency of late in the cement business has been to lengthen the kilns. A few years ago kilns measuring 60 feet were practically the standard, but kilns which are now being erected range from 80 to 125 feet in length, 100 feet being about the standard. In addition to the kilns Allis-Chalmers Co. will furnish a crushing plant consisting of one No. 6 "K" Gates rock and ore breaker, two No. 4 Gates breakers, and one No. 6 elevator. The operation of these is as follows: The No. 6 breaker receives the limestone as it comes from the quarry and does the preliminary crushing. The discharged product is divided and sent to the two No. 4 breakers, which prepare it for the grinding.

BUFFALO MEETING AMERICAN CHEMICAL SOCIETY.—There were some interesting exhibits at the recent convention of the American Chemical Society in Buffalo. The BUFFALO DENTAL MANUFACTURING COMPANY exhibited in the convention hall their full line of laboratory appliances, including muffle and crucible furnaces, gas burners of many types for laboratory purposes, laboratory foot blowers, gas furnaces, tube furnaces, vacuum pumps, gasoline gas generators, water heaters, etc. The BAUSCH & LOMB OPTICAL CO. exhibited some of their Baloc glassware for general laboratory purposes.

Articles of incorporation have been filed in Albany by the BAUSCH, LOMB, SAEGMULLER CO., manufacturers of engineering, astronomical, physical and other instruments of precision. The Bausch & Lomb Optical Co. is to be the sales agent of the new corporation, whose manufacturing plant is to be in the north end of the recently completed large addition to the

Bausch & Lomb factory in Rochester. George N. Saegmuller, of Washington, D. C., has been well and favorably known since 1890, when he succeeded Fauth & Co., old established makers of engineering and astronomical instruments. Many observatories in this country and abroad have been equipped by Mr. Saegmuller. One of the specialties of the firm has been the production of accurate graduations. The two automating dividing engines which are just being erected in the fireproof vault at the new Bausch & Lomb building, and to which soon a third will be added—are among the most accurate ever constructed. Since the circles which are used on engineering instruments are graduated on the same engines, their excellence has long been recognized. Mr. Saegmuller is perhaps best known to the engineering world as the inventor of the Solar attachment which bears his name. The work of transferring the plant from Washington to Rochester has been begun. Already five carloads of machinery and instruments have been unloaded, and are being placed in the new building. Associated with Mr. Saegmuller, who will continue as heretofore in active charge, are his sons, John L. and Fred. The latter is in Europe gathering facts relative to the latest developments in scientific instruments. It is the intention to establish a scientific bureau for computation and research on the lines of the celebrated Carl Zeiss Works, of Jena, the results to be available to both the Bausch & Lomb Optical Co. and the Bausch, Lomb, Saegmuller Co.

Personal.

On June 28, Amherst College conferred upon Henry Noel Potter, Westinghouse special engineer, the degree of Doctor of Science, in recognition of his achievements in scientific research and his contributions to the practical as well as theoretical knowledge in the field of electric furnace work, electric lighting and kindred subjects. Dr. Potter graduated from Amherst in 1891, receiving at that time the first B. S., cum laude, given by that institution. Since that time he has been connected with the Westinghouse companies. Dr. Potter has been instrumental in the introduction of the Nernst lamp in this country. He has done a large amount of work in the electric furnace field, especially on tube furnaces. Quite recently he has developed a new process for making silicon in the electric furnace, and has devised, in conjunction with Mr. A. B. Albro, a method of using silicon in the silicothermic reaction.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Electric Smelting and Reduction Processes.

(*Continued.*)

No. 602,747. April 19, 1898. Charles K. Harding, Chicago, Ill.

Produces phosphorus from phosphate rock containing tricalcic phosphate. The rock is first pulverized and boiled for several hours with an excess of sulphuric acid of 20° Be., being continuously agitated. The liquid is filtered from the resulting sulphate of lime and boiled down to a syrup. The phosphoric oxide is then mixed with carbon and highly heated in a reverberatory furnace for several hours, in the presence of an excess of oxygen, thus driving off moisture and eliminating sulphur. More carbon is then preferably introduced into the furnace and parts of the oxygen are smelted out. The product, brought into a granular form by stirring and consisting of phosphoric or phosphorous oxides, or a mixture of the two, is then mixed with carbon and electrically smelted. The electric furnace has side walls of masonry, with a carbon lining at the upper portion serving as the anode, a non-conducting packing being interposed. The lower part of the lining and bottom are of silica, the bottom having a central hole through which passes the tubular carbon cathode. Around the cathode is an annular trough for the slag, leading to a tap-hole. The furnace rests upon a water-cooled metal base. During the smelting, gasoline is forced into the furnace through the cathode and is said to be electrolyzed as it enters the furnace, forming a zone of hydrogen gas around the end of the cathode, through which the current passes as an arc. The supply of gasoline is controlled by an electromagnetic valve in the main circuit. The gasoline serves as a reducing agent for the phosphorus in the slag. The vapors escaping from the furnace are suddenly expanded and cooled, being delivered to a condenser in which the phosphorus is liquified. The partial elimination of the sulphur in the roasting furnace and that of the remainder by combination with hydrogen from the gasoline, prevents the production of carbon disulphide in the electric furnace, which would otherwise dissolve the phosphorus and interfere with the reduction.

Nos. 602,975 and 602,976, April 26, 1898, Guillaume De Chalmot, Leaksville, North Carolina.

Produces the ferrosilicides Si_2Fe_2 and Si_2Fe and alloys of the two. A charge of silica or a silicate, *e. g.*, felspar or mica, mixed with iron or an iron ore and carbon, in the form of coke, coal, charcoal or pitch, is smelted in an electric furnace, the ferro-silicide being either tapped out, allowed to cool in the furnace and then separated from the slag, or allowed to settle on the bottom of the furnace, the slag being tapped off. A flux such as calcium or magnesium carbonates, hydrates or oxides, or soda and potash or other bases or their salts, may be added. With the minimum proportion of silica the product will be Si_2Fe_3. As the silica is increased, the product contains Si_2F in increasing amount, up to a product containing from 40 to 50 per cent of silicon. The materials should be pure to keep the slag low. A product low in silicon may be resmelted. A ferro-silicide containing from 10 to 13 per cent of silicon may be substituted for the iron or iron ore. An excess of the silicon compound is necessary to compensate for vaporization and incomplete reduction. The silicides are crystallized, those containing from 25 to 30 per cent of silicon being white, and those containing from 40 to 50 per cent being gray. They scratch glass, but not chrome steel, ruby or diamond. The alloys low in silicon can be melted in a combustion furnace and produce exact castings, which take a fine polish and do not tarnish in the air. The products are resistant to the action of ordinary acids and acid oxidizing agents, especially as the percentage of silicon increases, but dissolve in hydrofluoric acid. Those containing a small percentage of silicon are more resistant to aqueous alkaline solutions. The silicides are suitable for the production of anodes and chemical apparatus.

No. 656,353. Aug. 21, 1900, C. B. Jacobs, East Orange, N. J.

Produces alkaline earth-metal silicides $CaSi_2$, $BaSi_2$ and $SrSi_2$. A mixture of, *e. g.*, lime 56-60, quartz sand 120-130, and ground coke or anthracite, 60-70, is electrically smelted, preferably in the Bradley rotary furnace of patent 597,945, and the product accumulates on the hearth, where it is allowed to solidify. The silicides are white or bluish white substances of metallic appearance, resembling aluminium silicide and silicon. They have a crystalline fracture, like cast zinc. They oxidize slowly in the air, more rapidly when hot, yielding silicon dioxide. They decompose water, yielding hydrogen. The calcium compound decomposes more rapidly in hot water. The barium silicide decomposes in dilute acids, giving silicon hydride SiH_4, with free hydrogen. The calcium silicide reacts on dilute acids to give silico-acetylene, Si_2H_2, a bright yellow crystalline product. The strontium silicide reacts on dilute acids with the production of silicon hydride, free hydrogen and silico-acetylene.